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The Natural Food of some Malayan Mammals

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(Received June, 1959)

IN TWO PREVIOUS PAPERS on this subject, accounts have been given of the foodstuffs accepted by mammals in captivity (Harrison and Lim, 1950) and of the results of the examinations of the stomachs of rats and some other mammals caught by break-back traps (Harrison, 1954). As was explained in those papers, the preoccupation of the laboratory with ecto-parasites has precluded the catching of animals with killing traps except for special purposes. During the last few years, however, Colonel Traub of the United States Army Medical Research Unit in Malaya has been making special effort to obtain fleas, by shooting animals such as squirrels and immediately examining the body. Advantage has been taken of this supply of shot animals to review the knowledge of the stomach contents and it is the result of this survey that is presented here. At the same time, the opportunity has been taken to present the results of a large number of casual observations which have accumulated over the last decade, in addition to those reported in the earlier paper (Harrison, 1954).

Methods

Unless stated otherwise, therefore, all of the specimens discussed here have been killed at the time of capture; either shot with a shot gun or blowpipe (by an aboriginal collector), or else trapped in a break-back or other type of killing trap. Only the stomachs were examined, the examinations being carried out by eye with the help of a binocular dissecting microscope (or higher power when necessary), and a few simple chemical tests such as the iodine test for starch.

Foodstuffs in the stomach contents were allotted to broad groups, thus fragments of insects have been recorded as *insect* only, even though it was often possible to identify the insect to genus or even to species. The variety of insects found made the recording of species merely confusing. The name insect, by the way, has been used in a very broad sense.

As in the previous paper, it was found impracticable to identify the various substances of vegetable origin to be found in stomachs and they have been classified as: fruit; leaves (including green shoots); and other vegetable matter, the latter category appearing to comprise largely roots, tubers, and perhaps fungi.

No attempt was made to weigh the various fractions but relative proportions were estimated by eye. These abundances have been averaged over all stomachs examined to obtain the proportions of different food stuffs summarised in Table 1, which includes only animals killed in sufficient numbers. The final column shows the proportion of all animals examined which contained any insect matter at all.

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TABLE 1

Summary of the estimated proportions of different food types present in animals shot or otherwise killed.

Animals	No. exd.	Mean percentage of:				Contents unclassified	Percentage containing insects
		Insect	Fruit	Leaf	Vegetable		
Tupaia glis	5	90	10	..	..	..	100
T. minor	4	80	20	..	..	..	100
Cynocephalus variegatus ..	4	..	..	100	..	..	0
Paradoxurus hermaphroditus ..	6	10	40	..	5	45% snails	33
Petaurista petaurista ..	9	..	85	15	..	..	0
Callosciurus tenuis	21	15	60	..	25	..	76
C. caniceps	6	75	25	..	..	..	83
C. nigrovittatus	4	50	50	..	..	1 nearly empty	75
C. notatus	24	30	50	5	15	..	79
Rattus jalorensis	21	5	60	5	30	1 empty	40
R. argentiventer	17	50	..	..	50	1 snail	81
R. edwardsi[1]	4	50	..	..	50	..	100

1. The *R. edwardsi* were caught in live traps; contents estimated after allowing for bait.

Further notes are given on these and other mammals, examined species by species.

Insectivores

Tupaia glis (Diard) Greater Tree-Shrew

Five stomachs were examined. All contained insects and two contained some fruit also.

Tupaia minor Günther Lesser Tree-Shrew

Four stomachs were examined. All contained insects and two contained fruit also. In one of these two, the insect material was of caterpillers which might well have been feeding on the fruit.

Echinosorex gymnurus (Raffles) Moonrat

No stomachs of freshly killed members of this uncommon species have been examined, but the observations in the 1950 paper have been repeatedly confirmed, and specimens have been kept up to three years in captivity. The diet appears to be exclusively of fish, fresh water prawns, crabs, etc.

Hylomys suillus Müller — Short-tailed Shrew

Only two stomachs have been seen, one was empty, the other, of an animal caught in a live trap, contained tapioca bait and a number of crickets.

Suncus murinus (Linn) — House Shrew

Only four stomachs were examined of animals caught in live traps, and all were empty. This state of affairs however, seems to be frequent in insectivorous animals and can probably be taken as an indication that nothing but insects are eaten. This animal has been successfully reared and bred in captivity, and I am indebted to Mr. Lim Boo Liat for the following notes on its food in cages:

> During the past few years these shrews have been both kept in cages and successfully bred in captivity. Individuals live, in this way, more than two years. They are fed plain boiled rice, fresh prawns, ox liver, and cheese daily, with ten to twenty grasshoppers a week. Dead white mice are offered once a week, but not always eaten. The shrews are kept a pair to each cage, and about 150 grams of this mixed food is offered daily, of which each shrew eats 60 grams or more.

Crocidura malayana Robinson and Kloss — White-toothed Shrew

I use this name to refer to the White-toothed shrews to be found in forest. Two stomachs examined, both contained fragments of insects and the second contained also some vegetable matter which, however, probably came from the stomachs of the insects eaten.

Chimarrogale hantu Harrison — Water Shrew

All of the stomachs examined were empty, but as noted above this may indicate merely that it did not take vegetable matter, since digestion of the animal matter by shrews is very rapid.

Dermoptera

Cynocephalus variegatus (Audebert) — Flying Lemur

Four stomachs examined contained fragments of leaf only—apart from one stray ant which was not counted.

Primates

Nycticebus coucang (Boddaert) — Slow Loris

Three stomachs were examined from animals which had been caught in live traps. One contained unidentified seeds, the other two contained banana which was apparently used as a bait, and one of these contained fragments of banana leaves and shoots.

In captivity however, specimens take a large amount of animal food, not only insects, but also lizards, and the bodies of mice. Specimens have been kept up to ten years in captivity, and have mated and bred in a large outdoor cage.

Macaca irus Cuvier — Long-tailed Macaque Monkey

Two specimens shot within the municipal area of Kuala Lumpur had been feeding on garden fruits only. This is hardly a fair test, however, since they were shot as orchard pests. In captivity both this species, and *Macaca nemestrina* will take a great deal of animal food, such as insects and lizards; unlike the Leaf Monkeys (*Presbytis* spp.) which will normally take only leaves and fresh vegetables, and the Gibbons (*Hylobates* spp.) which will take little but fruit and vegetables.

Pholidota

Manis javanicus Desmarest — Pangolin

Two specimens had stomachs filled with ants. In one of them the stomach contents weighed 125 g. and were estimated to consist of 1,500 specimens of a large species and about 200,000 workers and pupae of a smaller species. The other specimen, which contained a few fragments of grass as well as the ants, had a number of stones in the stomach. The origin of these stones is unknown but it may indicate that the stomach which is thick-walled has some of the functions of the gizzard of a bird.

Carnivores

Viverra zibetha Linn. — Large Civet

One specimen examined killed by a car. The stomach contained one small monitor lizard (*Varanus* sp), one shrew (*Crocidura* sp), a cicada, a number of other insects, and some oil palm seeds.

Prinodon linsang (Hardwicke) — Linsang

Two stomachs have been examined from specimens shot. One was empty and the other contained the remains of a young ground squirrel, *Rhinosciurus laticaudatus*. I am indebted to Lim Boo Liat for the following observations on specimens in captivity:

> Our aboriginal trappers say that the Linsang feeds largely on birds, and on eggs taken from birds nests. In captivity we have kept them successfully on a diet of white-mice, dead rats and birds, ox liver, lizards, and fresh fish.

Paradoxurus hermaphroditus (Pallas) — House Musang

Six stomachs have been examined from freshly killed specimens. Four of the six stomachs contained fruit, including Sapodilla (*Achras zapota*) and *mata kuching* (*Nephelium malaiense*), both of which are widely cultivated, and an apple—presumably from a rubbish heap. Two of the stomachs contained insect material, one a large scorpion, while four stomachs in all contained snails, two of them nothing but snails. There was no evidence of their eating rats, although they are popularly supposed to chase rats in roof spaces, and captive specimens will readily eat both rats and birds.

Paguma larvata Smith — Masked Musang

No stomachs of freshly killed specimens have been examined, but specimens have been kept in captivity for many years. They thrive on a mixed diet of fruit, insects, lizards, mice, rats, birds, and meat of larger animals.

Arctictic binturong (Raffles) — Binturong

One stomach has been examined and has been commented upon before (Harrison 1952). It contained fruit, green vegetable, cooked meat and fish, and traces of a long dead chicken. Evidently it had been feeding at a rubbish dump. This behaviour is almost certainly unusual and in the present case, the animal, which was old and emaciated, had lost most of its teeth and was probably unable to eat the food normal for this species.

Ogilvie (1958b), states that they are "omnivorous; eating fruit, leaves, and shoots of favoured trees, as well as roosting birds . . . . They dive and swim under water in forest rivers and capture and bring to the bank goodly sized fish, which they devour at leisure."

Arctogalidia trivirgata (Gray) Three-striped musang

Two shot animals have been examined. The stomachs contained animal material only, namely beetles, frogs and a lizard. This does not seem to agree with observations made on captive animals which seem to prefer fruit to meat. In captivity it has proved difficult to persuade the animal to eat enough protein and there have been indications of protein deficiency. It is possible however that this species normally takes its protein in the form of insects and reptiles and not in the form of mammal or bird flesh which it was offered.

Felis bengalensis Kerr Leopard Cat

Six stomachs have been examined, of which four were empty except for a few blades of grass; the other two contained birds feathers, and parts of rats and frogs. This species is not easy to keep in captivity, but the following notes have been offered by Mr. Lim Boo Liat:

> Captive specimens of the Leopard Cat seem to have done quite well in captivity on a diet of white mice, the bodies of wild rats and birds, ox liver, boiled rice, fresh fish, eggs and even snails.

Felis planiceps Vigors and Horsfield Flat-headed Cat

Only one specimen has been seen. This was kept in captivity and Mr. Lim Boo Liat reports as follows:

> A young male Flat-headed cat was obtained from a Malay trapper, who had been keeping it for a while. It was in very bad condition when obtained, but it improved in captivity on a diet principally of fresh fish, together with white mice and eggs twice a week. Ox liver, and the bodies of lizards and birds were given occasionally, and milk daily. It developed an abscess on the canine tooth, and died suddenly of distemper after nine months of captivity.

Ungulates

Tragulus javanicus (Osbeck) Smaller Mouse deer

Only one stomach has been examined from a shot animal, and this contained unidentified fruits with a large nutty seed. Two further stomachs from animals caught in live traps also contained fruits of various kinds with large seeds, as well as miscellaneous debris (faeces and dead leaves which were within reach). The results although sparse, strongly suggest that the animal is primarily a fruit eater, a conclusion which agrees with the reports of the aboriginal trappers.

Rodents

Petaurista petaurista (Pallas) Spotted Giant Flying Squirrel

Nine stomachs were examined. All contained fruit and some contained leaves and shoots. There were no insects.

Pteromyscus pulverulentus (Günther) Smoky Flying Squirrel

One specimen of this rare flying squirrel has been seen. The stomach contained beetles and some white vegetable material, probably from the bait of a trap.

Hylopetes spp. Arrow-tailed Flying Squirrel

Only one stomach has been examined, from a trapped specimen, and it contained vegetable bait only. Ogilvie (1958a), however, gives an account of the food taken by a group of these squirrels in captivity. They fed principally on fresh fruit of various kinds, and rolled oats, but he records that on two occasions they attacked, killed, and ate tree snakes (*Ahaetulla*) which had made their way into the cage.

Iomys horsfieldi (Waterhouse) Horsfield's Flying Squirrel

Only one stomach was examined and contained fruit only.

Callosciurus tenuis (Horsfield) Slender Little Squirrel

Twenty-one stomachs were examined and as shown in the table they contained mostly fruit and various other vegetable materials, with a comparatively small amount of insects which, however, was present in the majority of the stomachs.

C. lowii (Thomas) Low's Little Squirrel

Two specimens were seen. One shot contained insects and fruit, the other caught in a live trap contained fruit only.

C. erythraeus (Pallas) Mountain Red-bellied Squirrel

Three shot specimens were seen. All contained some starchy vegetable matter and a fair proportion of insects.

C. caniceps (Gray) Grey-bellied Squirrel

Six shot specimens were seen. All contained fruit and all but one contained insects in varying proportions.

C. nigrovittatus (Horsfield) Black-banded Squirrel

Three shot specimens examined of which two contained insects, one being entirely empty. One of the three contained a large proportion of fruit and the stomach of one specimen caught in a live trap contained fruit only.

C. notatus (Boddaert) Common Red-bellied Squirrel

Twenty-four shot specimens examined. All of the stomachs contained fruit and nineteen of them contained insects in proportions varying from a trace to more than half of the total stomach contents. Several of these animals were shot in a rubber estate where they were accused of damaging the young rubber trees. There was little sign of bark in their stomachs, but one specimen had congealed rubber latex in the upper part of the stomach and in the mouth, and perhaps had been drinking the latex from a cup.

C. mcclellandi (Horsfield) Striped Little Squirrel

Two specimens shot, both contained insects and one some fruit in addition.

Dremomys rufigenis (Blanford) Red-cheeked Ground Squirrel

One specimen shot. The stomach contained roughly equal parts of insects (which had not been broken very much) and a white vegetable material probably some kind of root or tuber.

Ratufa bicolor (Sparrmann) Black Giant Squirrel

Two specimens shot. One stomach contained palm fruit only, the other both fruits and green shoots.

R. affinis (Raffles) Cream-coloured Giant Squirrel

Two specimens shot. The stomach contained fruit only.

Rhinosciurus laticaudatus (Müller) Shrew Faced Ground Squirrel

One specimen shot contained insects and earthworms.

Chiropodomys gliroides (Blyth) Pencil-tailed Tree Mouse

Only one specimen examined which contained nutty material.

Rattus jalorensis (Bonhote) Malayan Wood Rat

A further survey of this and following species was carried out using break-back traps in a number of localities different from those reported in 1954. As will be seen from the table, vegetable matter predominated in the present instance. Thirteen of these rats, which were trapped in the *Melastoma* scrub, contained very little but the berries of that plant. Seven others contained some trace of termites. Another eight from a different locality contained vegetable matter, apparently roots or tubers, with a higher proportion of insects, most of which were not termites.

Rattus argentiventer (Robinson and Kloss) Ricefield Rat

As noted above a further survey using break-back traps was carried out in two different localities. Seventeen of these specimens were obtained of which eleven contained both vegetable root matter and insects of various kinds including termites. Three contained vegetable matter only, two insects only, and one was full of snails.

R. exulans (Peale) Little Burmese Rat

Very few of this species have been examined. The only one worth noting contained a large proportion of snails as well as vegetable matter.

R. alticola (Thomas) Mountain Spiny Rat

The stomach of one specimen of this rather rare species was examined at Fraser's Hill in Malaya (the specimens reported in 1954 were from Borneo). This specimen, caught in a live trap, contained besides the tapioca bait, a large number of caterpillers.

R. edwardsi (Thomas) Edward's Giant Rat

Four specimens of this mountain species were caught in live traps at Fraser's Hill. All contained insects in varying proportions together with vegetable matter which could be accounted for by the bait in the trap.

Hystrix brachyura (Linn) Common Porcupine

Atherurus macrourus (Linn) Long Tailed Porcupine

No stomachs of porcupines have been examined, but both species have been kept for long periods in captivity. They thrive on a mixed vegetable and fruit diet the basic foodstuff offered being sweet potato and tapioca, with bananas and other fruit. They do not eat fresh animal food, but they seem to enjoy gnawing at bones, and they are reputed to destroy the tusks of dead elephants.

Conclusions

Broadly speaking these results agree with those presented in the earlier paper (Harrison 1954). The particular difference is that some species have been shown to eat more insects than was at first suspected. All of the tree squirrels of the genus *Callosciurus* are now found to eat insects in fair numbers. Two of these species *C. caniceps* and *C. nigrovittatus* were reported in the previous paper, on the strength of only a few examinations, to show little evidence of eating insects, but are now found to include a large proportion of insect in their diet.

Another difference is shown in the sample of *Rattus jalorensis*. The forty-three specimens examined in the previous survey had taken insects as roughly half the total food. In the present series twenty-one were examined and insects formed only a small proportion. Thirteen of the rats had been collected in an area of *Melastoma* bushes which were in fruit, and the stomach contents were almost exclusively of these berries. This species is evidently an opportunist in interesting contrast to *R. argentiventer* caught at the same time in the same general area which showed, as before roughly fifty per cent insect matter.

The following list combines the results of this and the previous paper, and presents a summary of the foodstuffs taken by the animals about which we can be reasonably certain. The sign (B) after a name indicates that the species occurs in Borneo and not in Malaya.

Insectivora

Tree-shrews	*Tupaia glis*	Insects with perhaps a little fruit.
	Tupaia minor	
	T. montana (B)	
	Dendrogale melanura (B)	
Shrews	*Suncus murinus*	Insects only.
	Crocidura malayana	
	Hylomys suillus	
	Chimarrogale hantu	
Moon Rat	*Echinosorex gymnurus*	Fish and other aquatic animals.

Dermoptera

Flying Lemur	*Cynocephalus variegatus*	Leaves only.

Primates

Slow Loris	*Nycticebus coucang*	Reptiles insects and fruit.
Macque Monkeys	*Macaca* spp.	
Leaf Monkeys	*Presbytis* spp.	Leaves only.
Gibbons	*Hylobates* spp.	Fruit and shoots.

Pholidota

Pangolin	*Manis javanica*	Ants

Carnivora

Civets	*Viverra zibetha*	Reptiles insects and fruit.
	Paradoxurus hermaphroditus	
	Arctictis binturong	
	Arctogalidia trivirgata	
Linsang	*Prionodon linsang*	Mammals and birds.
Cats	*Felis* spp.	

Artiodactyla

Mouse Deer	*Tragulus javanicus*	Fruit.

Rodentia

Flying Squirrels	*Aeromys tephoromelas* *Petaurista petaurista* *Iomys horsfieldii*	Fruit only.
	Hylopetes spp. *Pteromyscus pulverulentus*	Fruit and insects, etc.
Squirrels	*Ratufa bicolor* *R. affinis* *Lariscus insignis*	Fruit only.
	Callosciurus tenuis	Fruit and some insects.
	Callosciurus jentinki (B) *C. lowii* *C. caniceps* *C. nigrovittatus* *C. notatus* *C. albescens* (B) *C. mcclellandi*	Insects a major item with fruit.
	Callosciurus erythraeus *Dremomys everetti* (B) *D. rufigenis*	Insects with vegetable matter (not fruit).
	Rhinosciurus laticaudatus	Insects only.
Rats	*Chiropodomys gliroides* *Rattus canus*	Fruit no evidence of insects.
	Rattus bowersi *R. infraluteus* (B)	Vegetable matter only.
	Rattus exulans *R. mülleri* *R. cremoriventer* *R. whiteheadii*	Vegetable matter with some insects.
	Rattus jalorensis *R. argentiventer* *R. alticola* *R. rajah* *R. edwardsi* *R. sabanus*	Insects a major item with vegetable matter.

Discussion

The above taxonomic arrangement for presentation of the results, although convenient for reference, fails to emphasise some of the interesting features. In a paper reviewing the vertebrate fauna of Malaya for another purpose, I have attempted to

classify the Malayan forest animals according to their position relative to the canopy, and their time of activity (Harrison 1957 p. 412). In the following chart the animals listed above are classified in this way, and their foodstuff is indicated.

	Diurnal	Nocturnal
CANOPY	*Presbytis* spp L. *Hylobates* spp. F. *Ratufa* 2 spp. F.	*Aeromys, Petaurists, & Iomys* F. *Hylopetes, Pteromyscus* I F *Chiropodomys* F *Cynocephalus* L *Nycticebus* I F
UNDER-CANOPY	*Callosciurus* 6 spp. I F *C. erythaeus* I V *Tupaia* 2 spp. I (F) *Macaca* 2 spp. I F	*Paradoxurus, Arctictis & Arctogalidia* I F *Prinodon linsang* C *Rattus canus* F *R. cremoriventer* V I *Manis* I
GROUND	*Lariscus* F *Dremomys* I V *Rhinosciurus* I	*Rattus* 10 spp. I V *Rattus bowersi* V *Suncus, Crocidura, Chimarrogale, Hylomys, Echinosorex* I *Felis* 2 spp. C *Viverra* I F

CHART: F = Fruit, L = Leaves, I = Insect and reptile, etc., C = Bird & mammal flesh, V = vegetable, i.e., stem and root.

It will be seen at once that the distribution of feeding habit is not random. There is for instance an obvious tendency for the canopy animals to be fruit or leaf-eaters. This is brought out more clearly in Table 2 where the number of species of each habit are shown for each level and time. In the final column is shown the total proportion of all species taking animal food, a mixed feeder being classed as half animal and half vegetable eater.

TABLE 2

Distribution of feeding habit among mammal species shown in the chart. The number of species habit are shown.

Location	Type of Food taken						Proportion of animal food
	Plant only		Mixed		Animal only		
	Fruit and leaves	Vegetable	Fruit and Insect	Vegetable and Insect	Insect	Flesh	
Canopy:							
Diurnal ..	2	..	..	..	..	..	12%
Nocturnal ..	5	..	3	..	..	..	
Under Canopy:							
Diurnal ..	..	..	8	1	2	..	58%
Nocturnal ..	1	..	3	1	1	1	
Ground:							
Diurnal ..	1	..	..	1	1	..	64%
Nocturnal ..	..	1	1	10	5	2	

Three tendencies are obvious. First the animals of the canopy are predominantly plant feeders, and the proportion of animal feeders increases as the canopy is left behind. Secondly, the proportion of "mixed" feeders is highest in the under-canopy. Thirdly the plant food taken in the canopy is all fruit or leaves, but the proportion of vegetable matter increases to a majority at ground level.

The range of results presented, however, is obviously biassed in favour of rodents, and it would be as well, before proceeding further to see if these tendencies apply to the mammals as a whole. Accordingly Table 3 has been constructed, on the lines of Table 2, by allotting all of the mammals (other than bats) given in Harrison (1957: p. 412) to suitable feeding groups. To do this it has been necessary to resort to the informed guess, and the uncertainty as to the exact nature of the plant foodstuff taken by some of the forest animals has caused the abandoning of the two classes of plant food. All of the insectivores have been shown as animal feeders; pigs, bear, and the remaining civets as "mixed"; and the other ungulates as plant feeders. The five larger flying squirrels have been shown as plant and the five smaller as mixed feeders. One correction is necessary to the number of Ground Rats (*Rattus, Bandicota*) shown in the 1957 paper; the number should be fifteen, not nineteen as shown (which includes *Rhizomys* and the tree rats). As in that paper, an "intermediate" class of ground mammals is shown.

TABLE 3

Distribution of feeding habit of all mammals except bats, in Malayan Rain Forest (from chart in Harrison, 1957).

Location	Type of Food Taken				Proportion of animal food
	Plant	Mixed	Animal		
			Insect	Flesh	
Canopy:					
Diurnal	7	..	..	..	18%
Nocturnal	9	6	1	..	
Under Canopy:					
Diurnal	..	11	2	1	57%
Nocturnal	1	7	1	..	
Ground:					
Diurnal	1	1	1	..	
Intermediate	7	2	..	..	66%
Nocturnal	7	19	10	9	

Clearly Table 3 presents substantially the same picture as Table 2. The mammals of the canopy are predominantly plant feeders,—incidentally (although this is not shown) predominantly fruit and leaf eaters—and the proportion of animal feeders increases as the canopy is left behind; the proportion of "mixed" feeders is highest in the under-canopy (78 per cent as against 26 per cent for the canopy and 39 per cent for the ground); and (although this is not brought out in the table) the proportion of vegetable food taken certainly increases to a majority at ground level, although there is some uncertainty as to the exact proportions. It should be noted that the special conditions of rain forest, in which animal life is represented by many species, no one of which is specially abundant, makes it legitimate to compare numbers of species in this way.

To explain why this distribution should be found, it is helpful to compare the forest to the sea. The Malayan Rain Forest has a substantially closed canopy, and most of the photosynthesis must go on in that canopy, some thirty metres above the ground. The leaves, flowers, and fruits which grow here are, therefore, the primary source of food in the forest, just as the phyto-plankton of the sea surface is the primary source of foodstuff for the ocean life. Below the canopy the light penetrates effectively but a short way, and most of this light is used by the leaf layer of the under canopy, which, with regard to photosynthesis, may be considered merely as the lower extension of the canopy, and therefore, corresponds also to phyto-plankton. The bulk of the animal life of the canopy is, therefore, appropriately supported directly by the leaves, flowers (nectar), and fruits of the canopy, and may be likened to the zooplankton.

From the canopy the organic matter is carried downwards by three methods: physiologically by the tree-trunks and stems of lianes, perhaps to be stored in roots and tubers; directly in the form of fallen fruits, fallen leaves, and even fallen branches and trunks; and indirectly in the form of the bodies and excreta of the animals (including insects) feeding on the canopy. We thus have a class of ground animals, corresponding to the benthic fauna of the sea, feeding on this organic matter. The important supply of vegetable food at ground level is, as will be seen, not leaves and fruit, but stem and root, and it is vegetable matter of this sort which appears to provide the bulk of the plant food of ground mammals. Food of the second class, fallen fruit, leaves, and branches, is less certain, and is accordingly less exploited. Some ground animals, notably the Mouse Deer (*Tragulus*) appear to subsist very largely on fruit which must have fallen from above, a fact which provides an explanation of the small stature of this aberrant deer. Other, more faculative animals, such as the rats, accept fruit when it falls, but do not appear to rely on it. Fallen leaves and dead branches do not appear to provide a good direct source of food for the mammals, but they are exploited by fungi and insects, and the results of this exploitation are used by the animals, the flesh of the fungal fruiting bodies and the bodies of the insects. Insects are thus an important source of food for the ground mammals, while it is probable that a proportion of the indeterminate vegetable matter in the stomaches of rats may be fungal in origin.

The large proportion of insectivorous and carnivorous animals is thus a reflexion of the supply of organic matter in the form of animal bodies, both from this source, and by direct spread or fall from the canopy.

The larger ungulates appear to provide an exception to this scheme, in that, although ground dwelling, they are primarily browsing animals, subsisting on leaf material. The clue to this exception, however is given by the fact that animals of these groups are

best developed in more open country. They should not, perhaps be considered inhabitants of rain forest at all, but rather animals sheltering in the forest, but in fact feeding at the forest edge, where, for some reason or another the canopy is broken, and leafy vegetation is available at or near ground level.

The animals described as Under-canopy dwellers are those arboreal animals foraging underneath the canopy, rather than the inhabitants of what the botanist would regard as the under-canopy. They differ from the canopy dwellers in not being confined to the canopy, although they forage there freely, as well as among the lower tree trunks and even on the ground. They correspond in our marine analogy, to the free swimming nekton and the table makes it clear that they are characteristically *mixed* feeders. They comprise: the tree-squirrels, primarily fruit eaters but secondarily insectivorous; the tree-shrews primarily insectivorous but secondarily frugivorous; the tree-civets primarily carnivorous but secondarily frugivorous; and the macaque monkeys which are perhaps primarily omnivorous. It is probably to this omnivorous habit that we must look for an explanation of the under canopy habit. Such animals are not specialised feeders on canopy leaves and fruits; they are not specialised feeders on the roots, fungi, termites, and wood boring beetles of the forest floor; they eat anything which does not require a specialised digestive tract, and they go everywhere to find it. Their characteristic is, therefore, not that they have specialised for life in the under canopy, but that being unspecialised they move freely up and down, visiting canopy or ground as foodstuffs present themselves.

Only two truly carnivorous animals have been included in the under canopy group, the Marten, and the Linsang. It is probable that we should exclude carnivores from a classification such as this; they are at the top of the pyramid of numbers and will be found wherever other vertebrates are in sufficient numbers to support them. Carnivores are necessarily, however, comparatively large animals, and this limits their climbing powers. It is probable that several of the cats could fairly be regarded as under-canopy dwellers, in that they will climb freely to hunt their prey, although they have been shown in the ground level of the chart and tables above.

Summary

1. A recent attempt to collect fleas by shooting the hosts has provided a series of stomachs of freshly shot squirrels and other mammals for examination. The opportunity has been taken to summarise this and other information from stomach examinations collected over the last decade.

2. The feeding habits of some fifty-seven species of malaysian mammals are summarised from this information, foodstuffs being classified into leaves, fruit, vegetable material, insects, and other animal food. It is notable that most of the rodents (with the exception of the Giant Squirrels (*Ratufa*) and the Giant Flying Squirrels, are mixed feeders on both vegetable and insect material.

3. A scheme of the distribution of foodstuffs in rainforest is put forward.

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Notes on Aquatic Insects caught at Light in Malaya, with a Discussion of their Distribution and Dispersal

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Introduction

CAPTURES OF AQUATIC INSECTS at light have been recorded from many parts of the world. These records have been summarised by Fernando (1958, 1959, & in press). Although the phenomenon of flight at night of aquatic species and their attraction to light is a widespread phenomenon, yet, records are relatively few especially in Asia, where these insects have not been intensively studied. The present paper gives records of aquatic Hemiptera and Coleoptera captured at light in Malaya. The distribution of these species and their dispersal is discussed.

Previous records for the Malaysian region are those of d'Orchymont (1927) who mentions hydrophilid beetles at light. Dover (1929) describing a new species of *Corixa* states that the specimens were caught at light. Kitchener (1955) mentions in a general way that *Lethocerus indicus* (Lep. & Serv.) comes to artificial lights.

The material from which the present records were taken are the entomological collections at the Agricultural Research Station, Kuala Lumpur, the Rubber Research Institute, Kuala Lumpur and collections made by Mr. José Furtado at Batu Barendam, Malacca and the author in Penang. The Assistant Director of Agriculture (Research) in Kuala Lumpur has sent me large collections of insects taken in a light trap in Parit Satu, Tanjong Karang, Selangor amongst which were many aquatic species.

Whilst some of the species recorded in this paper are known to fly at night in other parts of Asia like *Lethocerus indicus, Micronecta quadristrigata* Breddin, *Helochares anachoralis* Sharp, *Berosus indicus* Mots., *Enochrus esuriens* (Walk.) and *Hydraticus fabricii* MacL., others are unusual records in that the species belong to families or genera not normally taken at light. To this category belong *Sphaerodema molestum* (Duf.) *Laccotrephes simulatus* Mont. *Plea liturata* (Fiedb.) and *Plea quinquemaculata* Lundb. Still others, although widely distributed in Asia and belonging to families and genera which are good fliers, have so far not been recorded at light. This is not surprising because light trapping for aquatic insects is practically unknown in Asia. The majority of species recorded in the present paper belong to the last category.

The flight of aquatic insects and their capture at artificial lights is a very interesting phenomenon. More important, however, is the distribution of species captured at light as compared with other species in the same area. It cannot be claimed that all species not captured at artificial lights do not fly. We do know for certain however, that those captured at light do fly. The limitations of light traps have been discussed by Popham and Lansbury (1960). It is evident from this and earlier studies, however, that in general the species taken at artificial lights are more widely distributed than the other species in the area. This makes it likely that flight at night is important in the dispersal of aquatic species.

The fact that a certain species is taken at light does not give any indication as to its range which is of importance in the dispersal over long distances. The means of dispersal is important to make the study more complete. The distribution of species and the possible means of dispersal have therefore been discussed.

Captures at Light

Aquatic insects belonging to the following families were recorded: Hebridae, Veliidae, Mesoveliidae, Gerridae, Nepidae, Belostomatidae, Corixidae, Notonectidae and Pleidae (Hemiptera-Heteroptera) and Hydrophilidae, Noteridae and Dytiscidae (Coleoptera). The numbers of each species taken and the locality and date of capture are given in TABLES 1 and 2.

Hemiptera-Heteroptera

Hebridae

A single specimen of *Hebrus sp.* was recorded (TABLE 1). The members of this family are not commonly recorded at light. Even if they do come to light they are probably missed because of their unattractive nature and small size. Hebridae have however been recorded in aerial plankton by Glick (1939).

Veliidae

One species, *Microvelia douglasi* Scott was recorded (TABLE 1). *Microvelia douglasi* is the most widely distributed veliid in Asia occuring in Japan, Formosa, India, Sumatra, Java, Malaya and Ceylon.

Veliidae have not been recorded at light to any great extent. The only records are those of White (1879) and Fernando (in press). They are of very small size and of little interest to anyone but the specialist, hence the paucity of records. *Microvelia spp.* have been taken in aerial plankton by Glick (1939).

Microvelia douglasi is a very common colonizer of small freshwater habitats in Malaya. It is found even in ephermeral pools. When new habitats are formed by human activities like road building, they are the first colonizers. They are common in paddy fields in buffalo wallows.

They are good fliers but probably have only a short range. They are probably transported over long distances by wind currents and also by human agencies as Laird (1956) has suggested.

Mesoveliidae

One species, *Mesovelia orientalis* Kirk. was recorded (TABLE 1). The Mesoveliidae are seldom recorded at light probably because of their small size. The only record I am aware of is that of White (1879). The members of this family are common enough in small isolated habitats and it seems likely that many species fly regularily. They have been recorded in aerial plankton by Glick (1939 & 1957).

Mesovelia orientalis is the most widely distributed member of the family in South East Asia and the Far East. It has been reported from Formosa, Philippines, New Guinea, Bali, Lombok, Sumatra, Java, Malaya, India and Ceylon.

Gerridae

Two species, *Limnogonus fossarum* (F.) and *L. nitidus* (Mayr.) were recorded (TABLE 1). Both these species have a very wide distribution. In fact they are the most widely distributed gerrids in South East Asia and the Far East.

Limnogonus fossarum has been reported from China, Philippines, Celebes, Java, Sumatra, Malaya and India. It is the commonest gerrid in Malaya and is often found in small pools of water. It shows a marked degree of alary polymorphism, the significance of which has been discussed by Brinkhurst (1959). The wide distribution of this species is probably due to its ability to fly.

Limnogonus nitidus is also a widely distributed species and has been reported from China, Formosa, Java, Malaya, India and Ceylon. Although less common than *Limnogonus fossarum,* it is nevertheless found in temporary habitats in many areas.

The Gerridae have not been recorded at light at any extent. *Limnogonus nitidus* (Mayr.) was recorded at light in Ceylon by Fernando (in press). Some species are however good fliers and have been recorded in flight during the day (Fernando 1959). Lundblad (1933) mentions that *Limnogonus fossarum* flies to lights.

Nepidae

One specimen of *Laccotrephes simulatus* Mont. was recorded (TABLE 1). This species is a common colonizer of temporary pools in the forests of Johore. It often breeds in these pools and is the commonest species of the genus in temporary habitats.

Laccotrephes simulatus occurs in China, Java and Malaya as known from present records but is perhaps more widely distributed. It is one of the more widely distributed species of the genus in South East Asia and the Far East.

The occurrence of Nepidae at light is very rare. I am aware of only one previous "record", a general remark that they fly at night in Swammerdam (1737). It seems likely that the nepids are represented today by species which do not fly to any great extent and were very widely distributed in the past.

Belostomatidae

Two species were recorded namely *Lethocerus indicus* (Lep. & Serv.) and *Sphaerodema molestum* (Duf.) (TABLE 1).

Lethocerus indicus was taken on five occasions on each of which only a single specimen was captured. This species is the most widely distributed aquatic hemipteren in Asia. It is however, not numerous in most localities. It occurs in China, Japan, Formosa, Philippines, Sumatra, Java, Malaya, Indo China, Burma and Ceylon (Lundblad 1933). In some countries it is used for food. It is called the "Electric Light" bug because of its habit of coming to artificial lights so often. It has been recorded at light or mentioned as coming to artificial lights by Kirkaldy (1901), Step (1925), Hoffmann (1931), Ramakrishna Aiyer and Anantanarayan (1934), Kitchener (1955) and Fernando (in press). It is a very powerful flier and probably flies long distances. This probably accounts for its very wide distribution.

Sphaerodema molestum was captured at light on three occasions. This is the first record of this widely distributed genus at light. A closely related species *Sphaerodema rusticum* (L.) occurs throughout South East Asia and the Far East. This species does not come to artificial lights and in Ceylon it is supposed to colonize habitats by swimming along temporary connections of water during the floods (Fernando 1960). In Ceylon where it is very common, it has not been found in isolated habitats. In Malaya it is very common but does not occur in isolated habitats whereas *Sphaerodema molestum* has been recorded in an isolated habitat in Mawai, Johore.

Sphaerodema molestum is not so widely distributed as *S. rusticum*. It occurs in India, Malaya and Sumatra. It is probable that flight is being selected against in this genus and the more widespread species *Sphaerodema rusticum* is represented by non-flying individuals which colonize habitats as Fernando has suggested, throughout its range.

Hungerford (1934) has suggested a careful revisional study of this genus which if done might throw light on the actual distribution and specific limits.

The records of Belostomatidae at light are given by Fernando (in press). Additional records are given in this paper. A single belostomatid has also been recorded at light in Africa by Southwood (1960).

Corixidae

Three species namely *Micronecta quadristrigata* Breddin, *M. scutellaris* Stal. and *Corixa connexa* (Lundb.) were recorded (TABLE 1).

Micronecta quadristrigata is a very widely distributed species occuring in the Philippines, Sumatra, Java, Malaya, India and Ceylon.

At Penang Hill I captured thousands of specimens at electric lights on four successive days 24th–27th October, 1960. On the 24th many thousands were seen at light shortly after dusk during heavy rain. On the 25th and 26th only about 50 specimens were seen each day at a single light. There was no rain on these two nights. On the 27th there was a shower of rain during the night and many hundreds were observed at a single light. A very similar record was made in Ceylon when thousands of specimens of the same species were caught at light during heavy monsoonal rains (Fernando, in press). Lundblad (1933) also records it at light.

Micronecta scutellaris has not been recorded in Malaya before. It is however very widely distributed occuring in the African and Oriental regions (Hutchinson 1940).

Corixa connexa is known from Sumatra. It is recorded here from Malaya for the first time. It is probably synonymous with *Corixa paivia* (Lundb.) according to Hutchinson (1940).

Corixidae are the commonest aquatic Hemiptera at artificial lights both in species and numbers. Their flight is often associated with heavy rain in the tropics (Fernando 1960 & in press). In temperate countries they fly during early spring and hot summer days (Fernando 1959 & Popham and Lansbury 1960).

The previous records of Corixidae have been summarised by Fernando (1959 & in press). Additional records are those of Meurer (1956 & 1957), Poisson, Richard, and Richard (1957 & 1958), Popham and Lansbury (1960) and Southwood (1960).

Although the larger species of Corixidae are capable of flying considerable distances, the smaller *Micronecta* are probably carried long distances in aerial plankton. Since flight is associated with monsoonal rains in the tropics and these rains are usually accompanied by storms. *Micronecta* spp. may be carried considerable distances. The wide distribution of *Micronecta quadristrigata* and *M. scutelloris* is accountable on this fact. There are relatively few species of *Micronecta* and Corixidae in general in South East Asia. If, as is here suggested some species are regularily dispersed. These would displace the local species.

Notonectidae

Two species namely *Anisops breddini* Kirk. and *A. nasuta* Fieb. were recorded (TABLE 1).

The genus *Anisops* and the Notonectidae in general are quite rare at artificial lights although many species are good fliers. The previous records are those of Hale (1924), Brooks (1951) and Fernando (in press). Brooks (1951) found only three specimens of a single species *Anisops bouvieri* Kirk. taken at light amongst the numerous species he examined.

Anisops breddini is a widely distributed species, occuring in India, Burma, Ceylon, Malaya and Celebes. *Anisops nasuta* is also widely distributed. According to Lundblad (1933), it is the most widely distributed species in South East Asia and the Far East. Brooks (1951) has however separated *Anisops nasuta* from a number of closely related species. The older records are therefore less reliable. The exact distribution of *Anisops nasuta* is difficult to assess. The distribution of the Notonectidae of Asia, is to say the least, incompletely known.

Anisops breddini is a very common species on Malaya. It is often found in small isolated habitats. In Johore and Singapore it is easily the commonest notonectid.

Pleidae

Two species were recorded namely *Plea liturata* Kirk. and *P. quiuquemaculata* Lundb. (TABLE 1). *Plea liturata* is widely distributed occuring in India, Java, New Caledonia, and Malaya and is perhaps the most widely distributed member of the Pleidae in South East Asia and the Far East. *Plea quinquemaculata* was described in 1933 by Lundblad from Sumatra; it is here recorded from Malaya for the first time. Its distribution is poorly known.

The Pleidae have not been recorded at light before as far as I am aware.

Coleoptera

Hydrophilidae

Eighteen species were recorded (TABLE 2). Of these *Armostus crenulatus* Rég., *Mesosternum saundersi* Orch., *Cercyon puntigerum* Knisch, *Coelostoma falliciosum* Orch. and *C. vividum* Orch. generally live in damp earth. They are not commonly taken at artificial lights. Of the others, *Helochares anchoralis* Sharp, *H. pallens* MacL. *Enochrus esuriens* (Walk.), *Berosus indicus* Mots. and *Paracymus evanescens* Sharp have been recorded at light by d' Orchymont (1927) and Fernando (in press). The rest, *Helochares taprobanicus* Sharp, *H. minustissimus* Kuw., *H. abnormalis* Sharp, *Amphiops pedestris* Sharp, *Sternolophus rufipes* F. and *Enochrus rubrocinctus* Rég. have not been recorded at light before.

Of all the hydrophilidae in Malaya, *Enochrus esuriens, Helochares anchoralis,* H. *densus* and *Berosus indicus* are the commonest. These species are among the more widely distributed forms in South East Asia (Knisch 1924). They are all found in a wide variety of habitats and colonize isolated ponds.

The hydrophilid beetles are the commonest aquatic Coleoptera captured at artificial lights both in numbers and species. Their flight is often associated with heavy rains in the tropics. The previous records have been summarised by Fernando (1958 & in press).

The majority of hydrophilids are vegetarian and they often reach enormous numbers in habitats rich in decaying organic matter. They range through a wide variety of habitats occuring in streams, ponds, paddy fields and lakes.

Hydrophilidae have been recorded in aerial plankton by Hardy and Milne (1938), Freeman (1945) and Glick (1939 & 1957). Many small species are perhaps dispersed by wind currents.

Noteridae

Four species of this family namely *Hydrocoptus bosschae* Rég., *Canthydrus haagi* Wehn., *C. flammulatus* Sharp and *C. luctuosus* (Aube) were recorded (TABLE 2). The last named species has been reported at light by Fernando (in press).

These beetles are often considered a subfamily of the Dytiscidae. In Malaya they are very common and sometimes occur in enormous numbers. Both *Canthydrus flammulatus* and *C. haagi* number among the commoner water beetles of Malaya.

Dytiscidae

Fourteen species of this family were recorded namely *Cybister tripunctatus* Ol., *Hydraticus vittatus* F., *H. fabricii* MacL., *Hydrovatus ferrugatus* Rég., *H. bonvouloiri* Sharp, *H. acutus* Sharp, *H. accuminatus* Mots., *H. pumilus* Sharp, *H. tinctus* Sharp, *Laccophilus parvulus* Aubé, *L. chinensis inefficens* Walk., *Guignotus japonicus* Sharp, and *Copelatus pusillus* Sharp (TABLE 2).

Of these species, *Hydraticus fabricii* and *Laccophilus chinensis inefficens* have been recorded at light before, by Fernando (in press). Both these species are very widely distributed in South East Asia.

Cybister tripunctatus is perhaps the most widely distributed dytiscid in Asia. It also occurs in the Ethiopian and Australasian regions. *Hydrovatus* spp. form an important component of the water beetle fauna of Malaya. They are the commonest dytiscids in small stagnant habitats. *Guignotus japonicus* has been recorded in isolated habitats in Johore.

Dytiscidae are commonly taken at artificial lights. The previous records have been summarised by Fernando (1958 & in press).

The larger dytiscids like *Cybister tripunctatus* can fly long distances. The smaller species have been taken in aerial plankton (Glick 1939).

General Remarks

Fifteen species of aquatic Hemiptera and 35 species of aquatic Coleoptera have been recorded at light from chance collections. The wide variety of species representing most of the families of aquatic insects is in itself a very interesting fact. Previous records except those of Yamamoto (1951) and Fernando (in press) give relatively few species. At present, most records of aquatic insects at light are from temperate countries. It is likely that in tropical and sub-tropical regions flight at night is a commoner phenomenon and that many species are involved.

The correlation of species captured at light with their distribution gives some very interesting results. In the Hemiptera-Heteroptera where the distribution of South East Asian species is well known, Lundblad (1933) lists as being widely distributed in the area, seven species, namely *Laccotrephes robustus* Stal, *Sphaerodema rusticum, Micronecta quadristrigata, Anisops nasuta* Dist., *Mesovelia orientalis, Microvelia douglasi* and *Limnogonus fossarum*. These species in addition occur in a wide variety of habitats. Of these, *Laccotrephes robustus* and *Sphaerodema rusticum* do not fly and all the other species were recorded at light in Malaya.

The records of *Laccotrephes simulatus* and *Sphaerodema molestum* are interesting because these genera do not normally fly and the species recorded are not the most widely distributed members of the genera. It seems likely that most Nepidae and *Sphaerodema* spp. have lost their power of flight relatively recently as Lundblad (1933) suggests. It appears that flight is being selected against in these groups.

Lundblad (1933) noted the fact that the number of corixid species is relatively small in South East Asia. A possible explanation is that the species with marked powers of dispersal like *Micronecta quadristrigata* limit local speciation by competition.

Until such time as the distribution of aquatic Coleoptera in South East Asia is better known, it is difficult to assess the role played by dispersal in the distribution of species. It is known however that some of the species recorded at light in the present paper have a very wide distribution. *Cybister tripunctatus,* occurs as a number of subspecies in the Oriental, Ethiopian and Australasian Regions. Balfour-Browne (1945) states that the determination of these subspecies is difficult because their ranges overlap. *Helochares anchoralis, Enochrus esuriens, Berosus indicus, Paracymus evanescens, Laccophilus chinensis inefficens* and *Hydraticus fabricii* are very widely distributed in Asia. All these species have also been recorded at light before by Fernando (in press).

The majority of species recorded at light occur in a wide range of habitats. It is to be expected that a species with a high power of dispersal will find it an advantage to survive in a wide variety of habitats.

The means of dispersal of aquatic insects provides an interesting field for further investigation. The larger species recorded at light in this paper like *Lethocerus indicus, Corixa connexa, Cybister tripunctatus* and *Hydraticus vittatus* are capable of flying long distances. Most species, however, are probably carried by wind currents. Few records are available of aquatic insects in the atmosphere. This is due to a lack of study of the problem of wind dispersal. Aquatic insects have been recorded in aerial plankton in temperate regions by Hardy and Milne (1938), Freeman (1945) and Glick (1939 & 1957). A study of this problem in the tropics will probably give similar results.

The species most commonly taken in aerial plankton are small forms like *Hebrus, Microvelia, Mesovelia,* small corixids, hydrophilids and dytiscids. Lundblad (1933) suggests passive or active flight helped by winds as the chief means of their dispersal. Gressit (1954) has discussed the subject in some detail. He has suggested that insects may take advantage of seasonal variation in wind currents. Zimmerman (1948) considers storms an important agency in insect dispersal.

In tropical monsoonal countries like Northern Malaya, Ceylon and parts of India, flight of aquatic species is often associated with monsoonal rains (Fernando 1960). In general, monsoonal rains are accompanied by winds of considerable speed or even storms. This is an ideal situation for the dispersal of aquatic forms in the air. The climatic conditions during the monsoons act as a proximate factor in causing these insects to take to the air. They are then dispersed by the wind currents over considerable distances and the monsoonal rains provide suitable habitats which they then colonize.

Laird (1956) has suggested that human agencies may be responsible for the transport of small aquatic species. He given as an example, *Microvelia* which is transported from island to island in the South Pacific in this way. The transport of aquatic insects by human agency is perhaps of some importance since fish fry and fresh vegetables are transported in South East Asia under conditions where aquatic insects can survive easily.

Flight in aquatic insects is a strictly seasonal phenomenon restricted to relatively few days in the year (Fernando 1958, 1959 & 1960). It has been also shown that flight at night is an important factor in the colonization cycle of some species (Fernando 1960). That such flight is associated with monsoonal rains with marked wind currents,

indicates that the rigid restriction of flight period has evolved as an adaptation to colonize habitats and also disperse the species over a wide area. Also the seasonal dispersal of many aquatic insects even over short distances would account for the gradual spread of species under favourable condition as suggested by Fernando (1960).

Summary

Fifteen species of aquatic Hemiptera-Heteroptera and 35 species of aquatic Coleoptera were recorded at light in Malaya. Representatives of practically every family of aquatic insects are included in the catches although no regular trapping by light traps was made. The variety of species recorded is in itself interesting.

Notes are given of the species recorded especially in relation to their ecology in Malaya.

The species recorded at light are the more widely distributed members of the families. The exceptions are discussed.

The agencies responsible for the dispersal of aquatic insects are discussed. From the evidence it is probable that the regular monsoonal winds and storms play an important part in the dispersal of small species over long distances seasonally. The larger species fly considerable distances.

It is likely that flight at night is a regular phenomenon in some species and an integral part of the colonization cycle. It has evolved in association with favourable conditions like rain and wind currents.

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TABLE 1

Aquatic Hemiptera-Heteroptera taken at light in Malaya. Approximate counts are denoted by an asterisk (*).

Species	Locality and Date	Kuala Lumpur, Selangor, 3–10–31	Kuala Lumpur, Selangor, 23–11–37	Kuala Lumpur, Selangor, 5–5–41	Penang, 18–10–54	Alor Bukit, Kedah, 15–5–55	Parit Buntar, Perak, 14–6–55	Tanjong Karang, Selangor, 18–11–58	Petaling Jaya, Selangor, 17–4–59	Gemas, Johore, –4–60	Batu Barendam, Malacca, 3–10–60	Penang Hill, Penang, 24–10–60	Penang Hill, Penang, 25–10–60	Penang Hill, Penang, 26–10–60	Penang Hill, Penang, 27–10–60	Tanjong Karang, Selangor, 30–10–60	Tanjong Karang, Selangor, 16, 17–11–60	Tanjong Karang, Selangor, 28, 29–11–60
Habridae																		
Hebrus sp. ..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Veliidae																		
Microvelia douglasi	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	28
Mesoveliidae																		
Mesovelia orientalis	..	..	1	..	12	..	..	..	..	..	..	..	..	..	..	..	..	5
Gerridae																		
Limnogonus fossarum	..	..	..	..	..	..	..	6	..	2	..	..	..	..	..	..	12	26
L. nitidus ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	3
Nepidae																		
Laccotrephes simulatus ..		..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Belostomatidae																		
Lethocerus indicus	..	1	..	1	..	1	1	..	1	..	..	..	..	..	..	..	..	..
Sphaerodema molestum		..	..	..	..	..	..	12	..	..	..	..	..	..	..	..	2	6

TABLE 1—*continued*

Aquatic Hemiptera-Heteroptera taken at light in Malaya. Approximate counts are denoted by an asterisk (*).

Species	Locality and Date	Kuala Lumpur, Selangor, 3–10–31	Kuala Lumpur, Selangor, 23–11–37	Kuala Lumpur, Selangor, 5–5–41	Penang, 18–10–54	Alor Bukit, Kedah, 15–5–55	Parit Buntar, Perak, 14–6–55	Tanjong Karang, Selangor, 18–11–58	Petaling Jaya, Selangor, 17–4–59	Gemas, Johore, –4–60	Batu Barendam, Malacca, 3–10–60	Penang Hill, Penang, 24–10–60	Penang Hill, Penang, 25–10–60	Penang Hill, Penang, 26–10–60	Penang Hill, Penang, 27–10–60	Tanjong Karang, Selangor, 30–10–60	Tanjong Karang, Selangor, 16, 17–11–60	Tanjong Karang, Selangor, 28, 29–11–60
Corixidae																		
Corixa connexa	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	..
Micronecta quadristrigata		..	..	..	..	..	..	5	..	..	1,000*	1,000*	50*	50*	250*	17	1,000*	250*
M. scutellaris	..	..	..	..	..	..	..	..	..	..	8	..	..	..	..	..	..	5
Notonectidae																		
Anisops breddini	..	..	..	..	..	..	..	8	..	..	..	..	..	..	..	..	..	500*
A. nasuta ..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..
Pleidae																		
Plea liturata	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	50*
P. quinquemaculata	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8

TABLE 2

Aquatic Coleoptera taken at light in Malaya. Approximate counts are denoted by an asterisk (*).

Species	Locality and Date	Telok Anson, Perak, 4–5–28	Krian, Perak, 28–12–28	Kuala Lumpur, Selangor, 3–10–30	Kuala Lumpur, Selangor, 7–5–40	Parit Buntar, Perak, 1–11–55	Tanjong Karang, Selangor, 18–11–55	Gemas, Johore, –4–60	Batu Barendam, Malacca, 3–10–60	Penang Hill, Penang, 24–10–60	Penang Hill, Penang, 25–10–60	Penang Hill, Penang, 26–10–60	Tanjong Karang, Selangor, 30–10–60	Tanjong Karang, Selangor, 16, 17–11–60	Tanjong Karang, Selangor, 28, 29–11–60
Hydrophilidae:															
Armostus crenulatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	15
Mesosternum saundersi	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..
Coelostoma fallaciosum	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..
C. vividum	..	5	..	..	..	..	..	..	..	..	..	..	..	..	..
Cercyon puntigerum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Psalitrus sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Helochares anchoralis	..	..	..	..	..	..	1	..	..	..	..	..	..	3	3
H. minutissimus	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..
H. pallens	..	..	..	..	..	..	..	..	..	..	..	..	1	5	25*
H. taprobanicus	..	..	..	..	..	..	9	..	..	..	..	..	..	..	..
H. abnormalis	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10*
Enochrus esuriens	..	..	..	..	..	..	..	..	1	1	1	..	9	7	100*
E. rubrocinctus	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Enochrus sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Berosus indicus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	24
Paracymus evanescens	..	..	..	..	..	..	..	..	..	..	..	..	..	..	28
Amphiops pedestris	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
Sternolophus rufipes	..	..	..	..	..	..	..	..	..	..	..	..	..	53	..

TABLE 2—*continued*

Aquatic Coleoptera taken at light in Malaya. Approximate counts are denoted by an asterisk (*).

Species	Locality and Date	Telok Anson, Perak, 4–5–28	Krian, Perak, 28–12–28	Kuala Lumpur, Selangor, 3–10–30	Kuala Lumpur, Selangor, 7–5–40	Parit Buntar, Perak, 1–11–55	Tanjong Karang, Selangor, 18–11–55	Gemas, Johore, –4–60	Batu Barendam, Malacca, 3–10–60	Penang Hill, Penang, 24–10–60	Penang Hill, Penang, 25–10–60	Penang Hill, Penang, 26–10–60	Tanjong Karang, Selangor, 30–10–60	Tanjong Karang, Selangor, 16, 17–11–60	Tanjong Karang, Selangor, 28, 29–11–60
Noteridae:															
Hydrocoptus bosschae															3
Canthydrus haagi						18									
C. flammulatus														15	75*
C. luctuosus														6	10*
Dytiscidae:															
Cybister tripunctatus				1				1	1						
Hydraticus vittatus					2										
H. fabricii														24	
Hydrovatus confertus							18		1						10*
H. bonvouloiri			7												10*
H. ferrugatus							1		1						
H. acutus			12												100*
H. pumilus															3
H. accuminatus			1												100*
H. tinctus															5*
Laccophilus parvulus															5*
L. chinensis inefficens										1		1			
Copelatus pusillus												1		3	24
Guignotus japonicus												1			10*

Notes on a re-examination of some Bleeker type specimens of Indo-Malayan fresh-water fishes

Part 1, Cobitidae and Homalopteridae

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(Received July, 1961)

THE WHEREABOUTS of the Bleeker type specimens of fishes has been the subject of some confusion until Rofen (ms., in press) made it known that besides the British Museum (Natural History), London, a large proportion of the Bleeker collections is to be located in the Rijksmuseum van Natuurlijke Historie in Leiden. During the period February 1959 to March 1960, I was able to make a comparative examination of much of the Indo-Malayan Cyprinidae, Cobitidae and Homalopteridae in these two museums, as well as the collections in the Zoologisch Museum, Amsterdam. These notes have been prepared as a result of these studies.

In his *Catalogue of Fishes in the British Museum,* Gunther (1869) describes most of the Bleeker specimens as "typical" or as "type of the species". This appears to be founded mainly on the fact that Bleeker himself had originally offered them as types. A close comparison of these specimens against the original published descriptions has revealed that a few of them do not constitute type specimens. Where this has occurred I was usually able to locate the types in Leiden.

During his residence in Java, Bleeker was sometimes faced with an acute shortage of jars and other containers for his collections. On examining the collections in Leiden it was revealed that specimens from different localities were often placed in a single jar together with their respective types. It was possible only after a prolonged and critical examination to separate the types from some species. Among other criteria, the type specimens sometimes bore pencil marks and had been dissected to expose the branchiostegal rays. Separation was not feasible where large series had been intermixed.

The specimens are listed alphabetically below under the generic and specific names they were first described. I have in each case cited the original publication and this is followed on the next line, where necessary, by the current synonym or my own rediagnosis. Lectotypes and Paratypes are herein designated for the first time. They have been selected for all species regardless of my or any previous rediagnosis. In my notes on the specimens, the measurements and counts pertaining to the Lectotypes are given first. The figures in brackets refer to the Paratypes. The following abbreviations are used:—

BM . . British Museum (Natural History), London.
ML . . Rijksmuseum van Natuurlijke Historie, Leiden.

The species herein discussed are not represented by type specimens in the Zoologisch Museum, Amsterdam.

During the course of my work I received considerable assistance from Dr. M. Boeseman and Mr. A. J. de Lange at Leiden, Dr. E. Trewavas, Mr. A. C. Wheeler and Mr. G. Palmer at London and Mr. J. J. Hoedeman at the Zoologisch Museum, Amsterdam. I am indebted to them for their kindness.

Family COBITIDAE

ɔitis barbatuloides Bleeker

Nat. Tijdschr. Ned. Indie, 1851, vol. 2, p. 435.
= *Cobitichthys barbatuloides* (Bleeker).

HOLOTYPE: ML 4960, Sambas, Borneo, J. Einthoven.

The specimen is almost beyond recognition. Bleeker originally described it as with, later (1858–59, p. 304) as without suborbital spines. I have found an indication of a orbital groove. Considering the present condition of the specimen, it is possible that ıes may have been present.

ɔitis choirorhynchos Bleeker

Nat. Tijdschr. Ned. Indie, 1854, vol. 7, p. 95.
= *Acantopsis choirorhynchos* (Bleeker).

LECTOTYPE: ML 4977, Confluence of River Lamatang and River Enim, Palembang vince, Sumatra, P. S. van Bloemen Waanders.

PARATYPES (2): ML 2397, same data.

Dorsal iii.11 (iii.10); anal iii.5 (iii.5); pectoral i.9 (i.9 for 1 specimen); ventral i.6). The following measurements do not include one of the paratypes which has a ıaged snout: total length 166 mm. (caudal broken in paratype); standard length mm. (150 mm.); depth 8.5 (10.4); head 4.0 (3.9); eye 8.9 (9.4); snout 1.4 (1.3); torbital 3.6 (3.9). The body markings are still clearly seen.

The earliest spelling of the generic name *Acantopsis* van Hasselt (1823) is used here ɔreference to *Acanthopsis* of subsequent authors.

ɔitis hymenophysa Bleeker

Nat. Tijdschr. Ned. Indie, 1852, vol. 3, p. 602.
= *Botia hymenophysa* (Bleeker).

HOLOTYPE: ML 7059, Palembang, Sumatra, J. M. Van Leer.

Dorsal iv.12; anal vi.5; pectoral i.14; ventral i.7; total length 95 mm.; standard length 7 mm.; depth 4.3; head 3.4; eye 6.8; snout 1.8. The transverse markings on the body quite distinct.

ɔitis jaklesii Bleeker

Nat. Tijdschr. Ned. Indie, 1852, vol. 3, p. 604.
= *Nemacheilus jaklesii* (Bleeker).

LECTOTYPE: ML 7055, Pajacombo, Sumatra, P. Jakles.

PARATYPES: (2): ML 8949, same data.

Dorsal iv.9 (iv.9); anal iv.5 (iii.5); pectoral i.11 (i.10 & i.11); ventral i.7 (i.7); total gth 78.8 mm. (caudal broken in paratypes); standard length 58.7 mm. (59.4 mm. & 1 mm.); depth 6.7 (6.1 & 7.1); head 4.9 (4.6); eye 4.7 (4.8 & 4.9); snout 2.6 (2.6). eral line complete. Origin of dorsal fin in front of ventrals. Ventrals not reaching anus. ctotype with a suborbital hook. Barbels all less than diameter of eye; maxillary pair far the longest and equal to about 0.9 times eye diameter. The transverse body mark- s originally described by Bleeker are not visible. There is however a faint darkish pe along the lateral line terminating in a dark blotch at the caudal base.

The genus *Nemacheilus* Bleeker is in much need of revision. Weber & de Beaufort 16, p. 40) have synonymised the present species with *N. fasciatus* (Valenciennes). I

have not examined the type or topotypical specimens of that species and for the present I follow Bleeker (1863, p. 7) in considering the two as distinct.

Cobitis macracanthus Bleeker

Nat. Tijdschr. Ned. Indie, 1852, vol. 3, p. 603.

= *Botia macracanthus* (Bleeker).

LECTOTYPE: ML 7058, River Kwanten, Sumatra, H. W. Schwanenfeld.

PARATYPE: ML 9111, Palembang, Sumatra, J. M. Van Leer.

Dorsal iv.8 (iv.8); anal iv.5 (iv.5); pectoral i.15 (i.14); ventral i.8 (i.9); total length 132.0 mm. (58.5 mm.); standard length 93.0 mm. (41.4 mm.); depth 3.0 (3.2); head 3.1 (3.1); eye 5.9 (4.5); snout 1.9 (2.2). The characteristic markings on the head and body are still clearly seen.

Cobitis macrorhynchos Bleeker

Act. Soc. Sci. Indo-Neerl., 1857, vol. 2, p. 20.

= *Acantopsis dialuzona* van Hasselt.

LECTOTYPE: BM 1866.5.2.40, River Kahajan, Borneo, C. Helfrich *or* Batavia, Java, P. Bleeker.

PARATYPES (5): ML 7057, River Kahajan, Borneo and Batavia, Java, C. Helfrich and P. Bleeker.

The specimens have been mixed and I have no way of separating them by locality.

Dorsal iii.10 (iii.9–iii.10); anal iii.5 (iii.5); pectoral i.9 (i.9); ventral i.6 (i.6); total length 78.3 mm. (66.5–110.0 mm.); standard length 64.6 mm. (56.3–92.4 mm.); depth 9.2 (9.3–10.1); head 3.8 (3.9–4.6); eye 6.7 (7.9–9.9); snout 1.7 (1.6–1.7); postorbital 3.3 (2.9–3.3). Colouration, more or less uniform brown.

I have compared the series with the holotype of *A. dialuzona* van Hasselt (ML 2707) and follow Bleeker (1863, p. 9) in considering the two species as identical. I do not however agree with Weber and de Beaufort in synonymising the species with *A. choirorhynchos* (Bleeker). Besides the difference in colouration the species has relatively fewer dorsal rays, iii.9–iii.10 as against iii.10–iii.11.

Cobitis pfeifferi Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 298.

= *Nemachilus pfeifferi* (Bleeker).

LECTOTYPE: ML 7053, Lake Meninju, Sumatra, Ida Pfeiffer.

PARATYPES (4): ML 463, same data.

Dorsal iv.8 (iv.8); anal iii.5 (iii.5); pectoral i.10 (i.11–i.12); ventral i.7 (i.7); total length 60.0 mm. (56.8–58.0 mm.); standard length 48.2 mm. (44.5–46.8 mm.); depth 6.7 (6.1–7.7); head 5.1 (4.7–5.1); eye 5.6 (6.0–6.8); snout 2.7 (2.6–3.0). Lateral line complete. Origin of dorsal opposite or slightly behind that of ventrals. Ventrals not reaching anus. No suborbital hook. Barbels all longer than eye; outer rostral pair the longest and equal to 4–5 times eye diameter. The transverse body markings originally described are not visible. There is a faint darkish stripe along the lateral line and a dark transverse band on the caudal base.

Bleeker (1863, p. 7) and Weber & de Beaufort (1916, p. 40) have synonymised the species with *N. fasciatus* (Valenciennes). Having not seen specimens of that species I am for the present maintaining them as separate species. It would also be noted that there

are distinct differences between the present species and *N. jaklesii* in the number of transverse bands (Bleeker, 1863, p. 7), the length of the barbels and the position of the dorsal fin in relation to the ventrals. There would be no justification in synonymising *both* species with *N. fasciatus*.

Family HOMALOPTERIDAE

Homaloptera gymnogaster Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 163.

HOLOTYPE: BM 1866.5.2.49, Lake Meninju, Sumatra, Ida Pfeiffer.

Dorsal iii.7; anal iii.5; pectoral v.10; ventral ii.7; total length 73 mm.; standard length 60 mm.; depth 7.5; head 5.5; eye 4.4; snout 1.8.

Length of head 1.3 times its width. Barbels subequal, slightly less than eye diameter. Dorsal origin behind ventrals. Pectorals not reaching ventrals. Ventrals not reaching anus. Origin of anal nearer caudal base than that of ventrals. Scales not keeled. Abdomen naked except for a triangular patch extending before ventrals. Predorsals 32. Lateral line (several scales fallen off, partly estimated from scale pockets) 66, Bleeker gives 70. Scales between dorsal and lateral line 5½, between lateral line and ventrals 5½.

The specimen is in poor condition and I have not been able to make satisfactory notes on the colouration.

Homaloptera ophiolepis Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 160.

LECTOTYPE: ML 4986, Bandong, Java, H. Zollinger.

PARATYPE: ML 1929, same data.

Dorsal iii.8 (iii.8); anal iii.5 (iii.5); pectoral iv.11 (iv.11); ventral ii.8 (ii.8); total length 98 mm. (82 mm.); standard length 80.2 mm. (70.2 mm.); depth 10.8 (11.6); head 5.4 (5.4); eye 8.2 (7.2); snout 1.9 (1.9).

Length of head 1.4 times its width. Barbels slightly longer than eye diameter, rostrals slightly shorter than maxillary pair. Dorsal origin before ventrals. Pectorals not reaching ventrals. Ventrals reaching well beyond anus. Origin of anal nearer caudal base than that of ventrals. Scales keeled, excepting those near abdomen. Abdomen naked up to an oval patch extending behind the base of the pectorals. Predorsals 14 (14). Lateral line 47 (50). Scales between dorsal and lateral line 7½, between lateral line and ventrals 6½.

The specimens are bleached and without any indication of the original colouration.

Homaloptera polylepis Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 162.

= *Homaloptera ocellata* van der Hoeven.

I have not been able to satisfactorily locate the 2 cotypes from Buitenzorg, Tjpannas, Java. They are most probably included among the 13 specimens (ML 7049) which I have re-examined and compared with the holotype of *H. ocellata* van der Hoeven (ML 2723). The specimens all belong to the same species.

Homaloptera salusur Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 161.

LECTOTYPE: ML 5075, Batavia, Tjampea, Java, P. Bleeker.

PARATYPES (2): ML 8489, same data.

Dorsal iii.8 (iii.8); anal iii.5 (iii.5); pectoral vii.11 (vii.11); ventral ii.7 (ii.7); total length measurements are not possible because the caudal fins are broken (Bleeker gives 78–90 mm.); standard length 68.5 mm. (59.0 & 70.2 mm.); depth 6.7 (6.7 & 7.0); head 4.9 (4.6 & 5.0); eye 9.0 (7.6 & 7.8); snout 1.9 (1.8 & 1.9).

Length of head 1.5 times its width. Barbels shorter than eye, maxillary pair the longest. Dorsal origin before ventrals. Pectorals not reaching ventrals. Ventrals reaching well beyond anus. Origin of anal nearer base of ventrals than caudal base. Scales not keeled. Abdomen naked up to slightly before ventrals. Predorsals (estimated) 22 (24 & 25). Lateral line 62 (62). Scales between dorsal and lateral line 9 (8 & 10), between lateral line and ventrals 11 (9 & 10).

Colouration, more or less uniform brown.

Homaloptera wassinkii Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 163.

LECTOTYPE: ML 4987, Tjampea, Buitenzorg, Java, G. Wassink.

PARATYPES (2): ML 1934, same data.

Dorsal iii.7 (iii.7); anal iii.5 (iii.5); pectoral vi.10 (vi.11 & vi.12); ventral ii.7 (ii.7); total length 48.5 mm. (45.9 & 56.8 mm.); standard length 41.5 mm. (39.2 & 45.9 mm.); depth 7.2 (8.1 & 7.5); head 4.0 (4.4 & 4.2); eye 5.4 (6.8 & 5.7); snout 2.3 (2.1 & 2.2).

Length of head 1.3 times its width. Dorsal origin behind ventrals. Pectorals reaching ventrals. Ventrals not reaching anus. Origin of anal nearer caudal base than base of ventrals. Scales not keeled. Abdomen naked up to slightly behind base of ventrals. Lateral line 45 (42 & 45). Other scale counts not possible.

Colouration, more or less uniform brown.

Homaloptera zollingeri Bleeker

Nat. Tijdschr. Ned. Indie, 1853, vol. 4, p. 159.

The 3 cotypes collected by H. Zollinger from Batavia, Bandong, Java were lost (Bleeker, 1860, p. 89). In the absence of any topotypical material I have refrained from designating neotypes. The four specimens, BM 1866.5.2.53 (one) and ML 5075 (three) were collected by P. L. van Bloemen Waanders from Lahat, Sumatra.

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A Malayan record of the fresh-water medusa Craspedacusta sowerbyi Lankester (Trachomedusae, Petasidae)

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AND

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The occurrence of medusae in a disused mining pool near Ampang, Selangor, was brought to the notice of the authors by Mr. Hoh Lian Yong and Mr. Wong Phui Weng of the Rubber Research Institute, Kuala Lumpur. The first 13 specimens were collected by Mr. Hoh on the evening of January 22nd 1961, and given to us, still alive, the following day. Subsequently it has been possible to collect several hundreds within a few minutes using a simple dip net. The medusae occurred in very large numbers at some points on the edge of the pool, but none were caught at other points even by throwing a plankton net.

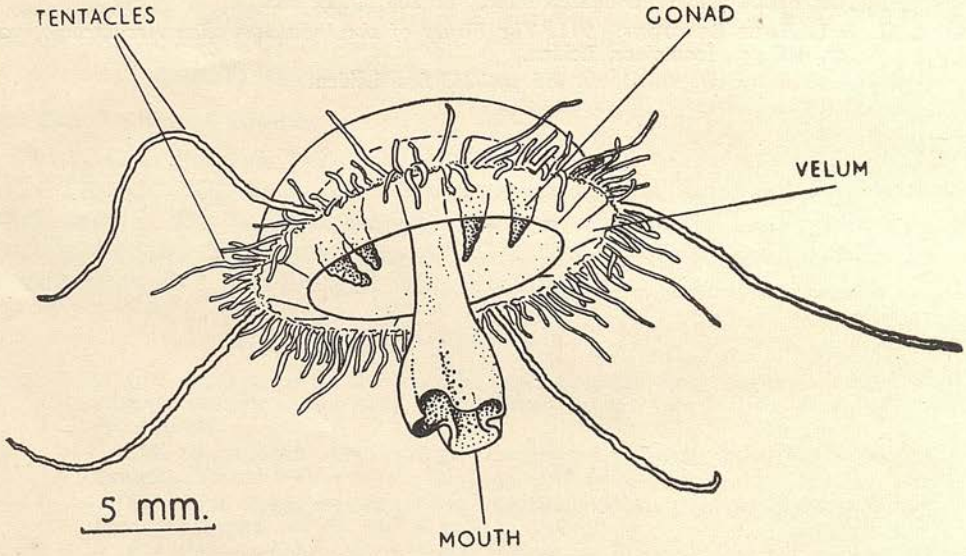

Fig. 1. *Craspedacusta sowerbyi* Lankester, from life.

The diameters of the live medusae ranged from 7 mm. to 20 mm. and shrank slightly on preservation. During movement the umbrella changes from almost flat to hemispherical in shape. There is a good marginal nematocyst ring and a broad velum. The mouth has four slightly folded lips which hang below the level of the umbrella margin. Four straight radial canals pass from the central stomach to the large ring canal, and four large, pouch-like gonads hang from the junction of the radial canals and stomach. There are up to 400 marginal tentacles in 3 main series:— long, medium, and short. The

longest are the four per-radials which are up to 2.5 cm. long in life, and which are inserted highest on the umbrella edge. The tentacles are covered with papillae bearing nematocysts. Up to 200 marginal vesicles are situated around the base of the velum, each containing a concretion and having a centripetal tube passing into the velum. (see Figure 1).

C. sowerbyi was first described by Lankester (1880), when it was found in water-lily tanks in London. It has since been found in aquaria, reservoirs, canals, and other standing bodies of water in many European countries, Russia, China, Japan, Australia, U.S.A., Panama, South America, and Hawaii. The present authors are unable to find any previous record of its occurrence in Malaya, although its known distribution indicates that it might be expected from almost any part of the world. A related genus, *Limnocnida* (Limnocnididae), occurs in Africa and India.

C. sowerbyi has also been known as *Limnocodium victoria* Allman (1880). It has a small hydroid stage of several polyps without tentacles which was named *Microhydra ryderi* Potts, 1885. A complete bibliography of *Craspedacusta* is given by Russel (1953).

So far only adult medusae have been found in one pool, but it is likely that *Craspedacusta* occurs in similar situations elsewhere in Malaya, and that the hydroid phase and young medusae will become available in time.

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Some Helminths from Elephants in Malaya

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(Received January, 1961)

Introduction

A COLLECTION OF helminth parasites from elephants in Malaya was made available to us through the kindness of Professor A. A. Sandosham, formerly Professor of Parasitology, University of Malaya, Singapore. Although the helminth parasites of the African and Indian elephant have been extensively studied since Cobbold's monograph of 1882, no records are so far available for Malaya.

The data available as regards the elephants from which the present material was collected is incomplete. One elephant is mentioned as being of "Indian origin" and the others as "Elephant in Malaya". It is probable that the latter records are for the Malayan elephant *Elephas maximus indicus* Cuv.

Sutherland, O'Sullivan and Ohman (1950) recorded the results of a post-mortem on an "Indian Elephant" imported to Australia from Singapore. It is possible that this elephant was of Malayan origin.

In the present paper we have recorded five species of Nematodes namely *Murshida murshida* Lane, *M. falcifera* (Cobbold), *Quilonia renniei* (Railliet and Henry), *Equinurbia sipunculiformis* (Baird) and *Choniangium epistomum* (Piana and Stazzi) and one species of amphistome trematode *Pfenderius papillatus* (Cobbold). Brief descriptions are given for each species with notes of interest in the material under study.

Description

Murshida murshida Lane. Plate 1, Figs. 1A, 1B & ID.

2 females 1 male, "stomach", Negri Sembilan, Malaya.

6 females 2 males, "stomach", Malaya 1937.

The male measures 18.2[1]–18.8 in length and has a maximum thickness of 0.64–0.8. The buccal capsule measures 0.08 in diameter. The Oesophagus is 0.51 long and the nerve ring is situated 0.4 from the anterior end. The spicules are equal, each measuring 1.39 and their tips are bent dorsally with a posteriorly directed spur at the angle.

The female measures 21.8–25.0 in length and 0.72–0.96 in thickness. The tail is 1.86 long and the vulva is 2.27 anterior to its tip. The eggs are oval and measure 0.0468 $\times$ 0.0216.

The genus *Murshida* was first described by Lane (1914) with *Murshida murshida* from the caecum of an Indian Elephant as the type species. Our specimens however are reported to have been collected from the "stomach".

1. All measurements are in millimeters.

This species is characterised, as Lane mentions, by the swollen bases of the lateral rays and the ruggedness of the dorsal rays, especially the externo-dorsal, of the bursa. The spur at the terminal bend of each spicule is another characteristic feature of this species. This was described as a "beak" by Lane (1914) and a "spur" at the angle of the bend of the spicule by Baylis (1936). The head end is as shown in Fig. 1a and is characteristic of the genus *Murshida*. It has a mouth collar and an external leaf crown which is shorter anteriorly and posteriorly than laterally. The mouth thus appears dorso-ventrally slit.

Murshida falcifera (Cobbold). Plate 1, Fig. 1C.

13 females 3 males, "stomach", Malaya 1937.

The male measures 21.0–23.9 in length and its maximum thickness is 0.83–1.04. The buccal capsule measures 0.16 in diameter and the length of the oesophagus averages 0.93. The nerve ring is 0.45 from the anterior end. The spicules are equal and measure 2.0 in length.

The female is 23.0–28.0 long and 0.83–1.06 in average maximum thickness. The vulva is situated at 2.72 from the tip of the tail which is 2.05 long.

This species unlike *Murshida murshida* does not have the bases of its lateral bursal rays swollen. The tips of the spicules resemble that of a golf stick as described by Baylis (1936) and it does not have the spur of *M. murshida*. The lip covering the vulva is inconspicuous.

The most characteristic distinguishing features between *M. murshida* and *M. falcifera* are the posterior spur of the spicule present in the former absent in the latter and the relative length of the oesophagus—it is about twice as long in the latter as in the former. Both species however, look very much alike on external examination.

Quiloina renniei (Raillet and Henry). Plate 1, Figs. 2A & 2B.

18 females 1 male, "stomach".

Negri Sembilan, Malaya 29.3.48.

The single male is 18.9 long and 0.7 in maximum thickness. The oesophagus measure 0.8 in length and the nerve ring is situated 0.36 from the anterior end. The buccal capsule is 0.144 wide and the elements of the external leaf crown counted without the aid of an "en face" mount approximated to eighteen. The spicules are fine, and equal in length each measuring 1.1. The bursa is as shown in Fig. 2b the dorsal ray being 0.36 long.

The females average 23.84 in length and 1.12 in maximum thickness. The vulva is situated at a distance of 7.0 from the tip of the tail which is 2.8 long. The eggs are oval in shape measuring 0.05 $\times$ 0.26.

The external measurements of our specimens vary somewhat from those given by Lane (1914) and quoted by Baylis (1936). Their male measured only 15.0 in length and 0.5 in maximum thickness. The measurements of internal structures such as the oesophagus and buccal capsule however agree. The discrepancies in the total length and thickness of the worms may be due to differences in preservation and also normal variation within the species.

The genus *Quilonia* is characterised by the few long elements of the external leaf crown and the wide separation, as seen in Fig. 2a, between the wall of the buccal cavity and the lining of the mouth capsule. *Quilonia renniei* differs from the other species parasitic in the Indian Elephant, *Q. travancara,* in having 18 elements to the external leaf crown and a short dorsal ray of the bursa, measuring 0.35, Lane (1914).

Equinurbia sipunculiformis (Baird). Plate 1, Fig. 3.

1 female, "stomach", Malaya 1937.

This specimen is 20.7 long and 1.6 thick at the widest portion. Its buccal capsule is 0.32 wide at its anteriormost end and the oesophagus 2.16 long. The vulva is situated on a cuticular prominence 0.56 from the tip of the tail which is 0.48 long. The eggs are oval measuring 0.064–0.032.

This specimen was identified as *Equinurbia sipunculiformis* by the characteristic head end and by the cuticular prominence on which the vulva is situated. It has a "subglobular" buccal capsule without teeth in its depth and tilted slightly dorsally, so that the mouth opens antero-dorsally. The external leaf crown is very characteristic projecting above the anterior end of the worm and having two short elements between two long elements as shown in Fig. 3.

Choniamgium epistomum (Piana and Stazzi).

1 female 3 males from elephant faeces. Kedah, Malaya, 18.9.47.

The elephant was of Indian origin.

The males are 21.0–22.0 long and 0.56–0.61 in maximum thickness. Its elongated buccal capsule is 0.4 wide, just below the origin of the external leaf crown and 0.64 long, gradually tapering towards the oesophagus to about a quarter of its original width. The spicules measure 2.0, are equal, and taper finely to their curved points. The externo-lateral ray gives off a branch dorsally and the dorsal bifurcates half way down its length.

The single female specimen is 21.7 long and 0.72 thick. The tail is missing together with the anal opening and the vulva opens 0.32 from this severed end.

The very long buccal capsule with a dorsally tilted mouth surrounded by a converging external leaf crown made up of very fine elements and the branching of the externo-lateral ray of the bursa are very characteristic of *Choniangium*.

Pfenderius papillatus (Cobbold). Plate 1, Fig. 4.

106 specimens, small intestine.

Negri Sembilan, Malaya, 29.3.48.

The specimens were much contracted and therefore unsuitable for detailed study. They measure 2.2 in length and 1.9 in breadth. In structure they conform to the genus *Pfenderius*. The characteristic large cirrus, measuring 0.5, posterior evagination of the oral sucker and wavy caecae are well marked. In size it resembles *Pfenderius birmanicus* Bhalerao but the shape of the caecae distinguishes it easily from this species. It agrees with the detailed description of *Pfenderius papillatus* given by Fukui (1929). All the specimens are immature in that no eggs were present. Bhalerao (1933), recorded *Pfenderius papillatus* which measured 2.1 long and 1.85 broad which, like our specimens, were immature.

Summary

Five species of bursate nematodes and an amphistomous trematode from Elephants in Malaya are described briefly.

Interesting features in the material under study are discussed.

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Explanation of Plate 1

1A. *Murshida murshida,* ventral view of head.

1B. *M. murshida,* lateral view of bursa.

1C. *M. falcifera,* lateral view of spicules and gubernaculum.

1D. *M. murshida,* ventral view of spicules.

2A. *Quilonia renniei,* lateral view of head.

2B. *Q. renniei,* lateral view of bursa.

3. *Equinurbia sipunculiformis,* ventral view of head.

4. *Pfenderius papillatus,* immature specimen.

A Synopsis of the Decapoda Caridea and Stenopodidea of Singapore, with notes on their distribution and a key to the genera of Caridea occurring in Malayan waters

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(Received February, 1961)

Introduction

THE DECAPODA Caridea and Stenopodidea of the Indo-Australian Archipelago, especially those of its eastern portion, are rather well-known. In general this is also true of the area extending from eastern Peninsular India to the Andamans and Peninsular Thailand. By contrast there are few published records of members of either of these groups from the Malayan area. Thus there are many species which are known both from areas to the north-west of Malaya and areas to the south-east of Malaya, but which have not yet been reported from Malayan waters. It is possible that certain of these do not occur in the Malayan area, especially its southern portion, since the extensive shallow water seas surrounding the south of Malaya must be unfavourable to many oceanic species. Nonetheless it is abundantly clear that the present paucity of records does not truly represent the real nature of the Malayan fauna.

Singapore is ideally located for a study of the crustacea of this south Malayan area. It is in the very centre of the system of shallow Malaysian seas. Around its shores there are representatives of almost every type of coast-line found in this region, from mud-flats and mangrove swamps to coral-reefs. There are also extensive brackish-water areas and several types of freshwater habitat. Thus a list of the Decapoda Caridea and Stenopodidea of Singapore would form a desirable addition to our knowledge of this group of animals. Though this listing is admittedly incomplete it does include far more species than have been recorded from any other single locality in the Indo-Pacific region and it is hoped that all of the commoner species and most of the less common species have been included.

There are very few published records of Caridea and Stenopodidea from Singapore. Thus the present list is almost entirely based on collections which I have been able to examine myself. These include: the non-Alpheid material of the Bedford-Lanchester collection and some other specimens housed in the British Museum (Natural History), London; some specimens in the collection of the Rijksmuseum van Natuurlijke Historie, Leiden; the collections of the former Singapore Regional Fisheries Research Station, at present housed in the Department of Zoology, University of Malaya in Singapore; a small collection made by Mr. Patton on a visit to Singapore and donated to this department; the main portion of the Archer collection, housed in the Liverpool Free Public Museums; and collections made by myself and my colleagues and students in this department. In the preparation of this list I have also examined for the purposes of comparison many specimens of non-Singaporean origin housed in the above museums and

also in the Zoologisch Museum at Amsterdam and the Zoology Museum of Cambridge University. The work could not have reached its present state had it not been for a grant of study leave by the authorities of the University of Malaya, which enabled me to visit the European museums mentioned. I wish to thank the authorities of all the institutions mentioned for their assistance. My thanks are also due to all who have helped in this work and especially to my colleagues who have borne with and encouraged my enthusiasm, to Dr. Isabella Gordon and Mr. R. Ingle of the British Museum for their unstinting help, and to Dr. L. B. Holthuis of Leiden for his very useful advice and criticism.

In order to keep this paper of a reasonable length I have not included individual synonymies. Throughout I have followed the generic nomenclature of Holthuis (1955). With this exception the names used for species are those used in the Siboga monographs, except where otherwise indicated. The Atyidae are not included in the Siboga monographs. For this family I have followed Bouvier (1925), except where otherwise indicated.

In order to make this paper more useful to Malaysian zoologists I have included a key to the genera of Caridean prawns known from or likely to occur in Malayan waters. This key is based on the world key of Holthuis (1955) with some modifications and simplifications. At the end of this paper I have appended a reference-list of basic works on the Caridea and Stenopodidea of the Indo-Australian area, and a further list of other papers containing records of members of these groups occurring in Malaya and Peninsular Thailand.

Systematic Account

CARIDEA

Pasiphaeidae

The Pasiphaeidae are mainly members of the deep-sea plankton. Only one genus and species occurs in the shallow seas of Malaya.

Leptochela robusta Stimpson, 1860

This small prawn is a regular constituent of the plankton in the Singapore Straits. It is the only fully planktonic caridean found in Singapore waters.

Atyidae

The Atyidae are poorly represented in Singapore freshwaters, though abundant in low-salinity brackish waters.

Caridina gracilirostris De Man, 1892

In Singapore island this species is confined to low-salinity and, more rarely, high-salinity brackish waters and to adjoining freshwaters which are subject to tidal influence. In such localities it may be very numerous, though seldom abundant.

Caridina brachydactyla peninsularis Kemp, 1918

This species is not common in Singapore. I have collected it at Sungai Seletar in low-salinity brackish water and in freshwater subject to tidal influence. I have also found it in a freshwater stream just above the tidal area near Jurong village. There are specimens in the Bedford-Lanchester collection from Tanglin; but the species has not been found in that part of Singapore in recent years and may have been exterminated there by the increasing urbanization of Tanglin.

I have previously (Johnson, 1961) accepted the view of Bouvier (1925) that *C. brachydactyla* is a synonym of *C. nilotica* P. Roux. I now think that it is a valid species (Johnson, 1960 a). Singapore specimens, as well as all others which I have seen from Malaya, agree in all essential features with Kemp's types from Penang and I consider that *peninsularis* Kemp is a valid subspecies of *C. brachydactyla*.

Caridina propinqua De Man, 1908

C. propinqua is the most abundant member of its family in Singapore. It inhabits low-salinity brackish waters and adjoining freshwaters which are subject to tidal influence. It is often abundant in such habitats, and occurs everywhere in the island where they are found. Elsewhere *C. propinqua,* though essentially a brackish water form, is sometimes found in freshwaters which are not connected with the sea. It ranges from Lake Chilka through to Thailand and Malaya. Singapore is its most southerly known locality.

Caridina tonkinensis Bouvier, 1919

Like the preceeding species, *C. tonkinensis* characteristically inhabits low-salinity brackish waters. It is apparently somewhat rarer than *C. propinqua* and in Singapore it has so far only been found in the north-eastern portion of the island. I have collected in a number of similar localities in western Malaya. Until its recent discovery in Malaya (Johnson, 1961), *C. tonkinensis* was only known from the type-specimens collected by Sollaud at Tonkin.

Caridina weberi sumatrensis De Man, 1892

C. weberi sumatrensis is apparently rather rare in Malaya, though widely distributed. I have collected a single specimen from a shaded stretch of the Sungai Seletar, below the Nee Soon swamp forest, but above the tidal zone. It does not appear to extend into either the swamp forest or the tidal zone.

Pandalidae

With the exception of the aberrant *Chlorotocus*-group the members of this family are essentially cold-water organisms. Most tropical species are thus inhabitants of deep waters and would not be able to survive in the shallow seas around southern Malaya. Of the three species found in Singapore two belong to the *Chlorotocus*-group and only one is common. It is most unlikely that any further species will be discovered in this area.

Heterocarpoides levicarina (Bate), 1888

H. levicarina occurs in a small pocket of relatively deep water in the Singapore Straits which exceeds 70 metres in depth.

Chlorotocoides spinicauda (De Man), 1902

This species has been collected in a small pocket of relatively deep water in the Singapore Straits which exceeds 70 metres in depth. In the British Museum there are specimens collected by the cable-ship *Patrol* from 80 miles south of Penang. In the eastern part of the Indo-Australian Archipelago it occurs in similar and slightly lesser depths.

De Man assigned this species to the genus *Chlorotocus*. Kemp (1925) created for it the genus *Chlorotocoides,* an action which was undoubtedly correct.

Chlorotocella gracilis Balss, 1914

This small prawn is not very common; but it is widely distributed in Singapore waters. Young individuals have been taken in *Enhalus*-beds at Bedok and in *Sargassum*-beds at Pulau Sudong, in both places at extreme low-water spring tide mark. Adults have been taken offshore over clean bottoms at several localities in the Singapore Straits and on the crinoid grounds of the Johore Shoals at a depth of about 18 meters. It is probable that, at least as an adult, *C. gracilis* is sub-planktonic since it has sometimes been taken in plankton nets in the Singapore Straits. This habit would agree with its slender, compressed build and feeble swimming powers. The nearest previously recorded localities to Singapore are the Andaman Islands and Java.

Hippolytidae

The Hippolytidae of the Indo-Pacific region are morphologically varied; but, as compared with those of the northern Pacific, they are represented by comparatively few species. Many Indo-Pacific species are found in Singapore waters, including nearly two-thirds of those which are widely distributed. There are several notable absentees including: *Ligur uveae* (Borradaille), 1899; *Thoralus amboinensis* (De Man), 1888; *T. maldivensis* (Borradaille), 1915; *Latreutes anoplonyx* Kemp, 1914; *Tozeuma armatum* Paulson, 1875; *Lysmata dentata* (De Haan), 1841; *L. trisetacea* (Heller), 1861; *Hippolysmata kukenthali* (De Man), 1902; and *Merguia oligodon* (De Man), 1888. *M. oligodon* appears to have unusual habitat requirements and may well have been overlooked. *Latreutes anoplonyx,* which is possibly a commensal of Scyphozoans, has been collected in Malayan waters by the cable ship *Patrol,* 80 miles to the south of Penang (specimen in the British Museum), and so may well be found at Singapore in the future. *Tozeuma armatum* was recorded from Singapore by Stephensen (1927) but this record is very doubtful. It seems to be replaced in Singapore waters by the closely related *T. lanceolatum.* The remaining species all have pronouncedly oceanic distributions and so may well be really absent from the shallow seas around Singapore.

Saron marmoratus (Olivier), 1811

There is one male of this species in the Bedford-Lanchester collection which was taken from the shore at Blakang Mati. This is probably the most abundant and widely distributed species of coral-reef Hippolytid in the Indo-Pacific region. Its rarity at Singapore may well be a consequence of the enclosed nature and low salinity of the local seas.

Saron neglectus De Man, 1902

I have collected a single specimen of this species from the reef-flat at Pulau Sudong. I have also seen a specimen from a reef on the south-west coast of Singapore Island. This species is widely distributed in the Indo-Pacific region; but it appears to be rarer than *S. marmoratus.* In addition to the localities cited by Holthuis it occurs at Samoa (specimens collected by Whitnee in the British Museum).

Thor paschalis (Heller), 1862

Kemp (1916) recorded this species from Tanah Merah Besar, Singapore. It has not been collected here in recent years.

Hippolyte ventricosa H. Milne-Edwards, 1837

This species is a common inhabitant of littoral weed-beds, and is found amongst both *Enhalus* and *Sargassum*. It is also found amongst floating masses of *Sargassum*.

Latreutes mucronatus (Stimpson), 1860

L. mucronatus is apparently rare in the Singapore area. Young individuals have been collected in *Enhalus*-beds at Bedok and Changi.

Latreutes porcinus Kemp, 1916

L. porcinus is a regular inhabitant of *Halophyllum*-pools and *Enhalus*-beds. It has only been known previously from the Andaman islands.

Latreutes pygmaeus Nobili, 1904

L. pygmaeus is a regular inhabitant of *Enhalus*- and *Sargassum*-beds. It is not known from other habitats in the Singapore area.

Tozeuma lanceolatum Stimpson, 1860

This is an offshore species. It has been collected at various localities in the Singapore Straits, down to depths of over 70 metres, and on the crinoid grounds of the Johore Shoals at a depth of about 18 metres. It has been occasionally taken in plankton nets in the Singapore Straits and is probably sub-planktonic. It occurs over clean bottoms of shell-gravel, coral-brash, etc.

I follow Holthuis (1955) in adopting the generic name *Tozeuma,* since this work is likely to remain the standard work on caridean genera for many years to come. There is only one species of the genus in Singapore waters, as far as I can determine. In view of the confusion that formerly prevailed in this genus I consider that Stephensen's (1927) record of *T. armatum* from Singapore almost certainly refers to the present species.

Singapore specimens, in their long rostrum, relatively short and broad antennal scale, and numerous ventral rostral teeth, agree with *T. lanceolatum* rather than with *T. armatum*. *T. lanceolatum* has only previously been known from Hong Kong; but there are specimens in the British Museum from Fukien. It is possible that some of the more north-easterly records of *T. armatum,* as for instance that of Balss (1914) from Japan, really refer to *T. lanceolatum*.

Gelastocaris paronae (Nobili), 1905

G. paronae occurs on clean gravelly bottoms in depths of 18 to 70 metres. It has been taken on the crinoid grounds of the Johore Shoals and in the Singapore Straits. In life it bears a marked resemblance to a cirolanid Isopod and it probably has similar habits.

Mimocaris heterocarpoides Nobili, 1903

There are seven specimens of this rare species in the collections of the department of zoology. They were collected off Singapore at some date prior to October 1951 by an unknown collector. The species is otherwise known from eastern Sumatra and north-western Borneo.

Hippolysmata (Hippolysmata) vittata Stimpson, 1860

This is probably the most abundant caridean of Singapore offshore waters. It is generally distributed on clean bottoms in depths of from 0 to over 70 metres; but it does not occur above low water spring tide mark. Specific localities include: Sultan Shoal,

around coral-heads on pier; Singapore Straits, several localities at varying depths on bottoms varying from gravelly to rocky.

Hippolysmata (Exhippolysmata) ensirostris Kemp, 1914

Both the typical form of this species and the form *punctata* Kemp are found in Singapore waters. It is apparently a species of shallow waters with sandy bottoms. Specific localities include: the shallow waters just below low-water spring tide mark off the Bedok-Siglap coast, where it may be very abundant, and the Singapore Straits to the south of Bedok in a depth of 40 metres.

Hippolysmata (Lysmatella) prima (Borradaile), 1915

This species is less common in the Singapore area than are the two preceeding species. It has been collected once in the Singapore Straits and once from an unspecified locality, where it was associated with a large sea-anemone living on a bottom of mixed mud and shell-gravel.

Alpheidae

The Alpheidae are the most abundant and varied family of marine Caridea in the Indo-Pacific region. Unfortunately the family is in need of a thorough revision so that the identification of individual specimens is difficult and sometimes impossible. Thus several of the identifications in the following list are somewhat uncertain. This is indicated by a ? preceeding the trivial name. There are a number of species of the genus *Alpheus* which occur in Singapore waters; but which I am unable to identify, even tentatively, with any known species. Some of these may be new species; others probably belong to previously known but inadequately described species. I have omitted these forms from my list since no useful purpose can be served by the mere listing of undescribed specimens under code designations.

Athanas parvus De Man, 1910

This species has been found on coral at the reef edge of Pulau Hantu.

Athanas jedanensis De Man, 1910

A. jedanensis occurs in the Singapore Straits at a depth of between 38 and 40 metres on a crinoid ground with gravelly-stony bottom.

Athanas monoceros (Heller), 1861

A single male was obtained from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong; a female was obtained from crevices in coral-rock on the lower beach at Labrador. These specimens were intermediate in character between *A. monoceros* Heller and *A. dimorphus* Ortmann, 1894. I consider that these two species are synonymous. *A. monoceros* has clear priority as the specific name.

Salmoneus hilarulus (De Man), 1910

Several specimens of this species have been collected from flats of very soft mud at Tanjong Penuru; a single male was obtained from dredgings on the shell-gravel, coral-brash grounds in Selat Sinki. The species was previously known from the type-specimen collected at a depth of 32 metres between Misool and New Guinea, on a bottom of sand and shells.

Jousseaumea De Man, used in the Siboga report, appears to be pre-occupied by *Jousseaumia* Sacco, a genus of molluscs. Holthuis (1955) proposed that the former genus be named *Salmoneus*.

Synalpheus sp. (*laevimanus* group)

This species is certainly a member of the *laevimanus* group; but it is quite unlike any described species known to me. It is found in crevices of honeycomb rock on the lower beach at Labrador and the reef-flat at Pulau Hantu.

Synalpheus amboinae (Zehntner), 1894

S. amboinae occurs on the crinoid grounds of the Johore shoals at a depth of about 18 metres; on the Ajax-Sultan Shoal at a depth of about 17 metres; and at various localities in the Singapore Straits in depths of down to over 70 metres. It is known from similar localities in the eastern portion of the Indo-Australian archipelago in depths of down to 40 metres. Its occurrence on crinoid grounds, together with its general form and colouration, suggest that it is a crinoid commensal, though this cannot yet be said to be proved.

Synalpheus comatularum (Haswell), 1882

This species was recorded from Singapore by Walker (1887). I could not find the specimen in my short visit to Liverpool and the record must be considered doubtful.

Synalpheus stimpsoni (De Man), 1888

S. stimpsoni is a commensal of comatulid crinoids. It has been collected from these organisms at Raffles Light.

Synalpheus neomeris (De Man), 1897

This species has been collected from a small area of deep water in the Singapore Straits which reaches a depth of over 70 metres.

Synalpheus gravieri Coutière, 1905

S. gravieri occurs on hard bottoms in the Singapore Straits at depths of between 35 and 70 metres. Collections made on the Outer Shoal suggest that it may be commensal with Alcyonaceans.

Synalpheus iphinoe De Man, 1909

S. iphinoe is found on the crinoid grounds of the Johore Shoals at a depth of about 18 metres. It has been recorded from similar localities in the eastern portion of the Indo-Australian archipelago in depths of from 18 to 90 metres. On the Johore Shoals it appears to be commensal with *Telesto*.

Synalpheus jedanensis De Man, 1909

S. jedanensis occurs on the crinoid grounds of the Johore Shoals at a depth of about 18 metres. It was originally described from pearl banks in the Aru islands at a depth of 13 metres.

Synalpheus triunguiculatus (Paulson), 1875

A single male has been collected from a bushy alcyonacean on the Outer Shoal.

Synalpheus stormi De Man, 1910

De Man (1910; 1911) treated this as a variety of *Synalpheus bakeri* Coutière, 1908; but there seems to be no clear reason why it should not have full specific status. A single specimen has been collected from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong.

Synalpheus tumidomanus (Paulson), 1875

S. tumidomanus has been found on the reef-flat at Pulau Hantu associated with the dead part of living coral-heads.

Synalpheus acanthitelsonis Coutière, 1905

This is one of the commonest species of *Synalpheus* in the Singapore area. It is generally distributed on beaches below mid-tide level and in shallow offshore waters wherever the bottom has crevices in which it can live. Specific localities include: Labrador beach, crevices in honeycomb rock; Pulau Sudong, coral-head growing in a depth of 1 to 2 metres; Johore Shoals, crinoid grounds at a depth of about 18 metres; Kuala Johore, off Angler Bank at a depth of about 18 to 27 metres.

Synalpheus hilarulus De Man, 1910

One individual of this species has been collected on a submerged shoal to the west of Pulau Pawai in a depth of about 10 metres on a shell-gravel bottom.

Synalpheus exilipes Coutière, 1905

I prefer to treat this as a separate species, rather than as a variety of *S. biunguiculatus* (Stimpson). One specimen has been collected from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong.

Synalpheus bituberculatus De Man, 1910

S. bituberculatus has been collected from crevices in honeycomb rock on the lower beach at Labrador; from crevices on the reef-edge at Pulau Hantu; and from a submerged shoal west of Pulau Pawai in about 10 metres depth on shell-gravel.

Synalpheus quadrispinosus De Man, 1910

S. quadrispinosus occurs on the crinoid grounds of the Johore Shoals at a depth of about 18 metres. It has also been collected in the Singapore Straits. It appears to be commensal with crinoids.

Synalpheus neptunus (Dana), 1852

This species was recorded from Singapore by Walker (1887). The specimen is in the Archer collection.

Synalpheus theano De Man, 1910

S. theano has been collected on shell-gravel, coral-brash grounds in Selat Sinki at a depth of about 10 metres.

Synalpheus pescadorensis Coutière, 1905

S. pescadorensis has been collected from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong.

Alpheus ventrosus H. Milne Edwards, 1837

This species has been collected from a submerged coral-gorgonian ground to the west of Pulau Pawai in a depth of between 6 and 10 metres; from a submerged coral reef off Pulau Tembakul; and from sub-littoral coral at Raffles Light. *A. ventrosus* is a well-known commensal of living coral.

Alpheus splendidus Coutière, 1897

A single specimen of this species has been collected from a submerged coral-reef in a depth of about 6 metres off Pulau Tembakul to the east of Pulau Sakijang Pelepah.

Alpheus lutini Coutière, 1905

A. lutini has been collected from crevices in coral rock at Pulau Hantu.

Alpheus paralcyone Coutière, 1905

This species appears to be associated with living sponges and corals. It is a common offshore form. Specific localities include: Selat Sinki, shell-gravel, coral-brash grounds in a depth of about 10 metres, on living coral; off Pulau Tembakul to the east of Pulau Sakijang Pelepah, coral-reef in a depth of about 6 metres; off Tanjong Rhu, 4 metres, mud; Singapore Straits, various localities in depths of from 35 to over 70 metres; Johore Shoals, crinoid grounds, in a depth of about 18 metres.

Alpheus spongiarum Coutière, 1897

A. spongiarum is specialized for life inside massive sponges. It is found wherever such sponges occur at levels below low water spring tide level. Specific localities include: Selat Sinki, shell-gravel, coral-brash grounds at a depth of about 10 metres; Pulau Sudong, sponges growing on coral-heads in depths of 1 to 2 metres; Singapore Straits, hard bottoms at depths of between 35 and 70 metres; Johore Shoals, crinoid grounds, at a depth of about 18 metres; lower beach at Labrador, small heads of sponge attached to coral boulders.

Alpheus stanleyi Coutière, 1908

A. stanleyi has been collected on the shell-gravel, coral-brash grounds of Selat Sinki at a depth of about 10 metres.

Alpheus cf. **lanceloti** Coutière, 1905

A single specimen which belongs to this or a closely related species has been collected from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong.

Alpheus bengalensis Coutière, 1905

De Man treats this as a variety of *A. paracrinitus* Miers, 1881. Whilst this may ultimately turn out to be correct there is at present no evidence to support the use of a trinomial, so that I prefer to treat it as a full species. *A. bengalensis* is abundant in crevices of honeycomb rock at Labrador.

Alpheus alpheopsides Coutière, 1905

A. alpheopsides has been collected from a coral-head growing in a depth of 1 to 2 metres at Pulau Sudong, and from crevices in dead coral at about low water spring tide mark at Pulau Hantu.

Alpheus rapax Fabricius, 1798

This is by far the commonest large caridean prawn of Singapore beaches. An errant form, it is neither a burrower nor a crevice dweller, but wanders in and out with the tide. It is abundant on sandy beaches and reef-flats and it has been taken on muddy beaches. Specific localities include: Tanjong Gul; Labrador beach; Bedok; Mata Ikan; Changi; Tanjong Kranji; Pulau Hantu; and Raffles Light. Visual observations suggest that it occurs everywhere where there is an extensive flat beach.

Alpheus angustidigitus De Man, 1911

Since the characters of this form seem to be constant I prefer to treat it as a separate species rather than to follow De Man in treating it as a variety of *A. brevirostris* (Olivier), 1789. This species is very similar to the last in form and habits. It seems to be less common in the Singapore area. Specific records include: Labrador beach; mud-flats at Tanjong Penuru; shoal west of Pulau Pawai in a depth of about 12 metres.

Alpheus distinguendus De Man, 1909

This species has been obtained in beach seines on the muddy-sand beach at Bedok. It is very similar to *A. rapax* but it can readily be distinguished in life by its beautiful and distinctive colouration.

Alpheus rapacida De Man, 1908

This species occurs in abundance in burrows in a flat of very soft mud at about mid-tide level at Tanjong Penuru where it is associated with *Salmoneus hilarulus*. It has not so far been found elsewhere in the Singapore Area.

Alpheus bisincisus De Haan, 1849

A single ovigerous female of this species was dredged from a submerged coral reef in a depth of about 6 metres off Pulau Tembakul to the east of Pulau Sakijang Pelepah.

Alpheus microrhynchus De Man, 1897

A. microrhynchus is not uncommon in prawn ponds in Singapore island. These ponds are brackish with a high but variable salinity, and are situated in mangrove areas.

Alpheus edwardsi Audouin, 1826

This species was recorded from Singapore by Walker (1887); but examination of the specimen in the Archer collection has convinced me that it really is a specimen of *A. audouini*. Thus *A. edwardsi* should no longer appear in the Singapore list.

Alpheus audouini Coutière, 1905

A. audouini is one of the commoner littoral Alpheids of the Singapore area. It is essentially a reff-flat species. Specific localities include: Labrador, lower beach; Bedok, lower beach; Pulau Hantu, reef-flat; Burun Darat, reef-flat; Pulau Subar Laut, reef.

Alpheus sp. cf. **audouini** Coutière, 1905

A prawn which is very close to *A. audouini,* and keys out to that species in De Man's (1912) key, lives and breeds in the prawn ponds of the Jurong area.

Alpheus chiragricus H. Milne-Edwards, 1837

This species seems to be a common offshore form in the Singapore area. It has been collected from: off the Siglap obelisk on muddy-sand at a depth of 2 to 8 metres; off Tanjong Rhu, on mud at a depth of about 4 metres; and off Tanjong Stapa at a depth of nearly 50 metres.

Alpheus crassimanus Heller, 1865

Several specimens of this species were obtained from cavities in a piece of ship-worm infested, drifted bamboo at Changi beach; and 2 specimens have been collected from the middle beach at Bedok.

Alpheus pareuchirus Coutière, 1905

I have collected this species on the reef-flat at Pulau Sudong and it has also been collected from hard grounds in the Singapore Straits.

Alpheus cf. **leptochirus** Coutière, 1905

A female which appears to be close to this species was obtained from crevices in drifted, ship-worm infested bamboo at Changi; a similar female has been collected from a crinoid ground in a depth of about 45 metres in the Singapore Straits to the south of Bedok.

Alpheus cf. **maindroni** Coutière, 1898

A single specimen which probably belongs to this species has been collected on the reef at Pulau Hantu.

Alpheus parvirostris Dana, 1852

This is one of the commoner littoral Alpheids of the Singapore area. It is a crevice-dwelling species. Specific localities include: Labrador, crevices in honeycomb rock on lower beach; Pulau Hantu, crevices in honeycomb rock on reef-flat; and in coral-rock at the reef-edge; Raffles Light, crevices in *Heliopora*-heads at low water spring tide mark and crevices in sub-littoral coral rock.

Alpheus hippothoe De Man, 1888

I have collected this species from a submerged coral-reef at a depth of about 6 metres off Pulau Sakijang Pelepah. It has also been obtained from submerged stakes of permanent fish-traps in the Nanas channel to the north of Pulau Ubin.

Alpheus euchirus Dana, 1852

This is one of the commonest of Singapore Alpheid prawns. It is found in both littoral and offshore habitats. It is a crevice dweller and is thus limited to hard bottoms. Specific localities include: Labrador beach, crevices in honeycomb rock on the lower beach; Pulau Hantu, crevices in coral rock at the reef edge; Pulau Sudong, coral-heads growing in a depth of 1 to 2 metres; Selat Sinki, shell-gravel, coral-brash grounds at a depth of about 10 metres; off the main harbour breakwater; Ajax-Sultan shoal, on stone at a depth of about 17 metres; submerged coral reef off Pulau Tembakul to the east of Pulau Sakijang Pelepah at a depth of about 6 metres; Singapore Straits, various localities, on hard bottoms in depths of from 35 to just over 70 metres; off Tanjong Stapa, at a depth of nearly 50 meres on mud.

Processidae

Members of this family appear to be rare in the Singapore area.

Processa processa (Bate), 1888

A single specimen of this species has been collected from the *Enhalus*-zone of the beach at Changi. De Man (1920) lists the species from Singapore.

Processa australiensis Baker, 1907

This species has been collected from *Halophyllum*-pools at Changi beach. It is probably not a true weed-bed form. Singapore represents its most north-westerly locality.

Nikoides sibogae De Man, 1918

N. sibogae has been collected by push-netting on the sandy-beach at Siglap.

Palaemoninae

The Palaemoninae are well-represented in the Singapore area by marine, brackish, and freshwater species. The freshwater species include the most abundant decapod crustaceans in the local freshwater fauna.

The generic nomenclature used for this sub-family is that of the Official List of Generic Names in Zoology, and of Holthuis (1955). The genera *Leander, Leandrites,* and *Palaemon* correspond with the genus *Leander* of most zoologists, whilst the genus *Macrobrachium* corresponds with the *Palaemon* of most zoologists. However unfamiliar these names may be to many zoologists they must be accepted in the interests of promoting a stable nomenclature for this group.

Leander urocaridella Holthuis, 1950

I am not fully convinced that Holthuis was right in including this species in the genus *Leander* or even in this sub-family. There is much to be said for Borradaille's original assignation. Since, however, this is not the place for a full enquiry into this question I have tentatively followed Holthuis, though with reservations.

L. urocaridella is probably sub-planktonic in habits. It has been collected in various offshore habitats over bottoms of shell-gravel, coral-brash, and similar material. Though widely distributed around Singapore it does not appear to be a common species. Specific localities include: Johore Shoals, crinoid grounds at a depth of about 18 metres; Singapore Straits, two localities in depths of 38 to 40 metres and 45 to 58 metres respectively; Outer Shoal buoy, in plankton haul. The only other Malayan locality, known to me is off the Sembilan Islands, Perak, on shell-gravel, coral-brash at a depth of 45 to 80 metres.

Leander tenuicornis (Say), 1818

This is a characteristic but only moderately abundant inhabitant of littoral and offshore weed-beds around Singapore. It has been found both amongst *Enhalus* and *Sargassum* but is more frequent in the latter.

Leandrites deschampsi (Nobili), 1903

Singapore is the type-locality for this species. It has not yet been reported from other areas. It is abundant in suitable high-salinity, brackish waters in the Jurong and Sungai Seletar areas.

L. deschampsi was originally described as a species of *Leander*. Holthuis (1950) listed it under that generic name as a doubtful species. Subsequently (1952 a) he was able to re-examine the type-specimens and concluded that this was a valid species of the genus *Leandrites*. *Leandrites deschampsi* is very closely related to *L. indicus* Holthuis, 1950. In my opinion it is very probable that they will ultimately be considered to be subspecies of the same species; but, for the present, it is best to treat them as separate species.

Palaemon (Palaemon) serrifer (Stimpson), 1860

There are 12 specimens of this species in the Bedford-Lanchester collection which were collected from 'very low water' at Raffles Light. I have not seen any specimens collected in this area in recent years; but I have obtained specimens from tide-pools to the north of Kuantan, Pahang.

Until 1950, when Holthuis recorded it from Java and Madura, *P. serrifer* had not been known south of Hong Kong and the Pescadores. The present records help to fill in the large gap in the known distribution of this species.

At present *P. serrifer* is the only member of the sub-genus *Palaemon* known from Singapore; but two other species, *P. concinnus* Dana and *P. debilis* Dana, may yet be found there.

Palaemon (Palaeander) semmelinki (De Man), 1881

P. semmelinki was recorded from Singapore by Nobili (1903). It occurs in high-salinity prawn-ponds in various parts of the island; it is abundant in the high-salinity reaches of the Sungai Seletar; and it occurs over mud-flats at Tanjong Kranji. I have seen specimens from brackish waters in Penang Island and there are specimens in the British Museum collection from the Langkawi islands. Holthuis (1950) considers this as being essentially a marine species; but, in my experience, it is most abundant in high-salinity, brackish waters.

Palaemon (Exopalaemon) carinicauda Holthuis, 1950

Balss (1914) reported this species from Singapore. Kemp (1917) considered that this record was very doubtful, since the most southerly of its other recorded localities was Hong Kong. In view of subsequent discoveries Kemp's reasoning does not seem to be entirely sound. Nonetheless I think that his conclusion was correct, and that the species cannot be accepted as a member of the Singapore fauna. If a species of this sub-genus does occur at Singapore, itself a doubtful proposition, then it is most likely to be *Palaemon styliferus* H. Milne-Edwards, which is known from several Malaysian localities.

Macrobrachium rosenbergi (De Man), 1879

This species was recorded from Singapore by Walker (1887) under the name of *Palaemon carcinus*. The specimens are certainly members of this species.

M. rosenbergi is not uncommon in suitable freshwaters. It occurs in the reservoirs of the Singapore catchment area and at the Woodleigh waterworks. In other areas *M. rosenbergi* has been collected from brackish and marine habitats; but there are no certain non-freshwater records from Singapore.

Macrobrachium lanchesteri (De Man), 1911

This species occurs in abundance in a single large fishpond near the Sungai Simpang Kiri. A single specimen has been collected from the non-forest, freshwater stretch of the Sungai Seletar at Nee Soon village. It has not been found in any other ponds which I have investigated. This species is abundant in rice-lands and ponds in western Malaya; but it has not yet been found in southern Johore. This fact, combined with the rarity of the species in Singapore Island, suggests that *M. lanchesteri* has been accidentally introduced at the two known Singapore sites. Singapore is the most southerly locality for the species, which has a continental distribution.

Macrobrachium idae (Heller), 1862

In Singapore this species is only known from ponds in the Tanglin area, where it is uncommon.

Macrobrachium equidens (Dana), 1852

M. equidens is essentially an inhabitant of high-salinity, brackish waters; it is also sometimes found in the sea. It has been recorded from low salinity waters and freshwaters in other parts of its range; but it has not been found in such waters in Singapore. *M. equidens* is a regular inhabitant of prawn-ponds, where it breeds. It is also sometimes

abundant in mangrove creeks, such as the lower reaches of the Sungai Seletar. It has also been taken at Bedok beach in a fully marine habitat, where, however, heavy rains may temporarily reduce the local surface salinity to as little as 20 parts per thousand.

Macrobrachium trompi (De Man), 1879

M. trompi is abundant in acid-water forest streams in the Mandai Road and Nee Soon areas.

Macrobrachium pilimanus (De Man), 1879

M. pilimanus has been collected in streams in the Nee Soon swamp forest; but it is very rare there. The specimens correspond with *M. pilimanus* as strictly defined.

Macrobrachium scabriculum (Heller), 1862

There are a number of specimens of this species in the Bedford-Lanchester collection which were collected in the Tanglin area. They correspond in all important characters with *Palaemon dubius* Henderson and Matthai, 1910. I agree with Holthuis in considering that this species is a synonym of *Macrobrachium scabriculum*. Until now the most southerly known localities for this species in south-east Asia have been the island of Enganno to the west of Sumatra and the Padang lowland of Central Sumatra. The species has not been found in Singapore in recent years and may have been exterminated by the increasing urbanization of the Tanglin area.

Macrobrachium geron Holthuis, 1950

This species is not uncommon in streams in the Nee Soon swamp forest area. There are specimens in the British Museum collections from Bukit Timah and from the Singapore Botanic Gardens. I have recently collected it in some numbers from a stream on the northern face of Bukit Timah. Elsewhere in Malaya it is abundant in a number of fast-flowing, acid-water streams at least as far north as Merbau, near Kuala Selangor. Previously it had only been known on the basis of the single specimen described by Holthuis, which had been collected in the island of Banka, almost one hundred years before. A fuller account of the Malayan specimens will be published elsewhere.

Pontoniinae

In comparison with the Indo-Pacific area as a whole, Singapore seems to be poor in members of this sub-family. Many of those species which are known from Singapore are very abundant. The absence of many species from the Singapore list may reflect the fact that they are rare, commensal species, which are easily overlooked in general collecting.

Palaemonella pottsi (Borradaille), 1915

I have collected a single male with the colouration of this species from crinoids taken on a coral-gorgonian ground at a depth of 2 to 8 metres to the west of Pulau Pawai. There is also a single specimen in the Bedford-Lanchester collection from Singapore which appears to belong to this species, rather than to *P. vestigialis*.

I have re-examined Borradaille's types and cannot find any certain morphological characters in these or my own specimens which would serve to separate *P. pottsi* from *P. vestigialis*. However, the two forms differ markedly in coloration and ecology. *P. pottsi* is brightly pigmented and occurs associated with comatulid crinoids. *P. vestigialis* is hyaline in life, and is usually colourless when preserved. It is a coral associate. Holthuis

(1952), whilst suggesting that the two forms may ultimately prove to be conspecific, tentatively keeps them separate because of these differences. I am in full agreement with this procedure, especially since minute differences may well be revealed when it is possible to examine and compare closely extensive series of both species.

Palaemonella vestigialis Kemp, 1922

This species is closely associated with living coral. It is not uncommon on reefs around Singapore; but it is easily overlooked because of its small size and colourless, hyaline body. Specific localities include: Pasir Panjang, Bedford-Lanchester collection; Blakang Mati, Bedford-Lanchester collection; Pulau Hantu, reef; Pulau Sudong, reef and in crevices of large heads of *Pavona frondifera* growing in a depth of 1 to 2 metres; Raffles Light, on branching corals and *Heliopora*-heads; Rabbit Island (= Pulau Biola) 'very low water' on shoal, Bedford-Lanchester collection. The record from Pasir Panjang is somewhat puzzling. The locality is certainly not suitable for this species at the present day, and the name, which means 'long sands' suggests that it never has been. There may have been a small reef in the area 50 years ago which has vanished owing to the extensive silting which is still continuing on this coast. Alternatively the specimen may have come either from a submerged reef offshore or from a neighbouring area, such as Labrador.

As I have pointed out above this species cannot at present be distinguished from *P. pottsi* except on grounds of colouration and ecology. *P. pottsi* is the older name and will have to be used in the event that these two species should prove synonymous.

Periclimenes (Periclimenes) aesopius (Bate), 1863

This species is both very abundant and generally distributed in all types of littoral weed-beds around Singapore.

Periclimenes (Periclimenes) parvus Borradaille, 1898

There is a single specimen of this species in the Bedford-Lanchester collection which was obtained from 'outer coral' at 'very low tide' at Raffles Light

Periclimenes (Harpilius) spiniferus De Man, 1902

Specimens of this species were collected by Patton from sub-littoral corals at Raffles Light.

Periclimenes (Harpilius) amymone De Man, 1902

This species occurs on living coral-heads. It has been found at about low water spring tide mark at Tanjong Gul and on sub-littoral coral at Raffles Light.

Periclimenes (Harpilius) grandis (Stimpson), 1860

This is a regular but rather unimportant member of littoral weed-bed assemblages. It occurs in both *Enhalus* and *Sargassum*-beds. I have also collected it away from weed-beds at Burun Darat and around the piles of the pier of Sultan Shoal.

Periclimenes (Harpilius) cf. **lutescens** (Dana), 1852

This coral species has been collected by Patton from sub-littoral coral at Raffles Light.

Periclimenes (Harpilius) seychellensis Borradaille, 1915

This species is a dominant member of littoral weed-bed assemblages. It is found in both *Enhalus* and *Sargassum*-beds; but it is usually more abundant in the latter.

Periclimenes (Harpilius) suvadivensis Borradaille, 1915

This species occurs sparingly in *Enhalus*-beds at Changi and Bedok and in *Sargassum*-beds at Pulau Sudong.

Periclimenes elegans (Paulson), 1875

A single specimen of this species has been collected from *Enhalus*-beds at Changi.

Periclimenes (Harpilius) calmani Tattersall, 1921

This species occurs in abundance in mangrove channels in the Jurong area. It has also been found in *Enhalus*-beds adjacent to mangrove at Tanjong Gul.

Periclimenes (Harpilius) brooki (De Man), 1888

Two specimens of this species have been obtained from two different localities in the Singapore Straits at depths of about 40 metres and about 50 metres respectively.

Periclimenes (Harpilius) brevicarpalis (Schenkel), 1902

This species is an obligate commensal of giant sea-anemones of the genus *Stoichactis* and allied genera. It does not appear to be common around Singapore; but specimens have been obtained at Tanjong Penuru and Raffles Light.

Periclimenes (Harpilius) sp. nr. **digitalis** Kemp, 1922

A single specimen from the reef-flat at Burun Darat appears to belong to a new species allied to *P. digitalis* Kemp.

Anchistus custos (Forskal), 1775

This species is an obligate commensal of the bivalve *Pinna*. In the Singapore area it is the only prawn associated with this bivalve which is at all common. Most specimens of *Pinna* contain from one to four specimens of *Anchistus custos*. The species, which inhabits the mantle cavity, occurs wherever *Pinna* is found, i.e. on the lower beach of sandy and muddy-sandy beaches all round the island and the offshore islands.

Anchistus miersi (De Man), 1888

I have seen a single specimen of this species which was taken from the mantle cavity of a species of *Tridacna* collected off Singapore. Despite search, it has not been subsequently found.

Periclimenaeus tridentatus (Miers), 1884

This is the only species of *Periclimenaeus* which has been found in the Singapore area. A single male has been collected from a coral-gorgonian ground at a depth of 2 to 6 metres to the west of Pulau Pawai, and a female has been taken from a crevice in sub-littoral coral rock at Raffles Light. These records indicate that the species is in some way associated with coral, though they do not imply that it is necessarily a coral commensal. They give no support to Holthuis's (1952) conclusion that it is an associate of sponges and ascidians. The previously known distribution of this species was distinctly oceanic. Thus, these Singapore records are of considerable interest.

Philarius imperialis Kubo, 1940

A single ovigerous female has been collected from a coral-head at Tanjong Gul. *P. imperialis* was recorded from the Indo-Australian archipelago by Holthuis (1952) under the name *Philarius gerlachei* (Nobili), 1905, which is a very different species.

Harpiliopsis beaupresi (Audouin), 1825

Specimens of this species have been collected from sub-littoral coral at Raffles Light by Patton.

Coralliocaris graminea (Dana), 1852

Specimens of this species have been collected by Patton from sub-littoral coral at Raffles Light.

Conchodytes monodactylus Holthuis, 1952

There is a single specimen of this rare species in the British Museum collections, which was obtained from *Pinna atropurpurea* at Siglap, Singapore by R. Winckworth. It has only been known previously from Holthuis's (1952) specimens.

Crangonidae

Pontophilus angustirostris De Man, 1918

This species has been obtained from the Singapore Straits at a depth of between 35 and 70 metres, on a shell-gravel, coral-brash bottom. Another specimen was caught in a stramin net in the same area.

Pontophilus parvirostris Kemp, 1916

This species was obtained from a mud bottom at station SBA 1 by the Singapore Regional Fisheries Research Station, at a depth of over 90 metres. I have not been able to trace this station, which, whilst probably a Malayan locality, is unlikely to be within the Singapore area.

Pontocaris orientalis (Henderson), 1893

A single specimen of this species was obtained from the crinoid grounds of the Johore Shoals in a depth of about 18 metres. *Aegeon,* the name by which this genus is usually known, is an erroneous spelling of *Egeon* Bosc, 1813, which is an invalid, junior homonym of *Egeon* Montfort, 1808, a genus of Protozoa. Thus the name *Pontocaris* Bate, 1888 must be adopted.

STENOPODIDEA

Stenopodidae

The names Stenopidea and Stenopidae are sometimes used for this group; but are incorrectly formed according to the international rules. The Stenopodidae only include two genera in Malayan waters and only one species is known from Singapore.

Stenopus hispidus (Olivier), 1811

There are two specimens of this species in the Bedford-Lanchester collection. One, on ovigerous female, is from a shoal of Rabbit Island (= Pulau Biola) at 'very low water'. The other, a non-ovigerous female, is labelled as coming either from that locality or from a depth of 15 fathoms off Pulau Bukom. The latter locality is relatively improbable in view of the known ecology of this species. Pulau Biola is thus the only acceptable locality for this species in the Singapore area. Records in the literature suggest that this is a very common species; but it is distinctly rare at Singapore. In nine years we have not collected a single specimen.

General notes on distribution

There are nearly 100 species of Caridea and a single species of Stenopodidea known from Singapore. Many of these are uncommon. The following 39 species are common, at least locally, in suitable habitats: *Leptochela robusta; Caridina gracilirostris; C. propinqua; C. tonkinensis; Hippolyte ventricosa; Latreutes porcinus; L. pygmaeus; Hippolysmata vittata; H. ensirostris; Salmoneus hilarulus; Synalpheus amboinae; S. acanthitelsonis; S. bituberculatus; Alpheus ventrosus; A. paralcyone; A. bengalensis; A. spongiarum; A. rapax; A. angustidigitus; A. rapacida; A. chiragricus; A. microrhynchus; A. audouini; A. parvirostris; A. euchirus; Leander tenuicornis; Leandrites deschampsi; Palaemon semmelinki; Macrobrachium rosenbergi; M. lanchesteri; M. equidens; M. trompi; M. geron; Palaemonella vestigialis; Periclimenes aesopius; P. amymone; P. grandis; P. seychellensis;* and *Anchistus custos.*

No species occurs in all types of habitat or even in all types of marine habitat. Despite the rarity of many species the following summaries of distribution by habitat type may be of some interest. In these summaries an asterisk indicates that the habitat type is probably a minor one for the species concerned. Crevice-dwelling species are indicated by the symbol(cr) whilst commensals are indicated by the symbol(co). The latter have been listed separately under their hosts. The numbers in brackets are the total numbers of species recorded from the respective habitat types.

Freshwater species (11):

*Caridina brachydactyla peninsularis; *C. propinqua; *C. tonkinensis; C. weberi sumatrensis; Macrobrachium rosenbergi; M. lanchesteri; M. idae; M. trompi; M. pilimanus; M. scabriculum; M. geron.*

Low-salinity brackish waters (4):

**Caridina brachydactyla peninsularis; C. propinqua; C. tonkinensis; C. gracilirostris.*

High-salinity brackish waters (including prawn ponds) (6):

Alpheus microrhynchus; A. cf. *audouini; Leandrites deschampsi; Palaemon semmelinki; Macrobrachium equidens; Periclimenes calmani.*

Littoral weed-beds (16):

**Chlorotocella gracilis* (young); *Hippolyte ventricosa; Latreutes porcinus; L. mucronatus* (young); *L. pygmaeus; *Hippolysmata ensirostris; *Alpheus rapax; *Processa processa; *P. australiensis; Leander tenuicornis; Periclimenes aesopius; P. calmani; P. grandis; P. elegans; P. seychellensis; P. suvadivensis.*

Elsewhere on muddy beaches (6):

Salmoneus hilarulus; Alpheus rapax; A. angustidigitus; A. rapacida; Palaemon semmelinki; Anchistus custos (co).

Sandy and muddy-sandy beaches, excluding weed-bed forms (9):

*Hippolysmata ensirostris; *Alpheus audouini; A. crassimanus; A. rapax; A. distinguendus; Nikoides sibogae; *Macrobrachium equidens; Anchistus custos* (co); *Conchodytes monodactylus* (co).

Reef-flats and beaches of similar character, excluding weed-bed forms (21):

Saron marmoratus; S. neglectus; Athanas monoceros; Synalpheus tumidomanus (cr); *S. acanthitelsonis* (cr); *S. bituberculatus* (cr); *Synalpheus* sp. (*laevimanus* group) (cr); *Alpheus lutini* (cr); **A. spongiarum* (co); *A. bengalensis* (cr); *A. rapax; A. angustidigitus; A. audouini; A. pareuchirus* (cr); *A. parvirostris* (cr); *A. euchirus* (cr); *Palaemonella vestigialis; *Periclimenes amymone* (co); **P. grandis; Periclimenes* sp. nr. *digitalis; *Philarius imperialis* (co).

Reef-edges, excluding weed-bed forms (30):

*Saron neglectus; *Hippolysmata vittata; Athanas parvus; A. monoceros; Synalpheus stimpsoni* (co); *S. stormi* (cr); *S. acanthitelsonis* (cr); *S. exilipes* (cr); *S. bituberculatus* (cr); *S. pescadorensis* (cr); *Alpheus ventrosus* (co); *A. spongiarum* (co); *A.* cf. *lanceloti* (cr); *A. alpheopsides* (cr); *A. maindroni* (cr); *A. parvirostris* (cr); *A. euchirus* (cr); *Palaemon serrifer; Palaemonella vestigialis; Periclimenes parvus* (?co); *P. spiniferus* (co); *P. amymone* (co); *P. grandis* (co); *P.* cf. *lutescens* (co); *P. brevicarpalis* (co); *Anchistus miersi* (co); ***Periclimenaeus tridentatus*** **(cr)**; *Harpiliopsis beaupresi* (co); *Coralliocaris graminea* (co); *Stenopus hispidus.*

Soft bottoms offshore (3 to 4):

Hippolysmata ensirostris; H. prima (?co); *Alpheus chiragricus; ? Pontophilus parvirostris.*

Submerged coral-reefs (8):

Alpheus ventrosus (co); *A. splendidus* (co); *A. bisincisus; A. paralcyone* (co); *A. hippothoe* (cr); *A. euchirus* (cr); *Palaemonella pottsi* (co); *Periclimenaeus tridentatus* (cr).

Crinoid grounds (bottom usually of sand and shells with telestaceans), shell-gravel grounds, and other hard bottoms offshore, in depths of less than 70 metres (27):

*Chlorotocella gracilis; Tozeuma lanceolatum; Gelastocaris paronae; Hippolysmata vittata; Athanas jedanensis; *Salmoneus hilarulus; Synalpheus amboinae* (?co); *S. gravieri* (?co); *S. iphinoe* (co); *S. jedanensis; S. triunguiculatus* (?co); *S. acanthitelsonis* (cr); *S. hilarulus; S. bituberculatus* (cr); *S. quadrispinosus* (co); *S. theano; Alpheus paralcyone* (co); *A. spongiarum* (co); *A. stanleyi; A. angustidigitus; A. pareuchirus* (cr); *A.* cf. *leptochirus; A. euchirus* (cr); *Leander urocaridella; Periclimenes brocki; Pontophilus angustirostris; Pontocaris orientalis.*

Deep water species (in depths of over 70 metres) (8 to 9):

Heterocarpoides levicarina; Chlorotocoides spinicauda; Tozeuma lanceolatum; Hippolysmata vittata; Synalpheus amboinae (co); *S. neomeris; Alpheus paralcyone* (co); **A. euchirus* (cr); ? *Pontophilus parvirostris.*

Sub-planktonic (3):

Chlorotocella gracilis; Tozeuma lanceolatum; Leander urocaridella.

Planktonic (1):

Leptochela robusta.

In floating *Sargassum* (2):

Leander tenuicornis; Hippolyte ventricosa.

In drifted bamboo (2):

Alpheus crassimanus; A. cf. *leptochirus.*

Commensals (about 23):

A query before the specific name indicates that the occurence of the species at Singapore is doubtful. A query after the name indicates that the commensalism is presumptive only and not yet fully approved.

Of sponges (2):—

Alpheus paralcyone; A. spongiarum.

Of medusae (1):—

Latreutes mucronatus (not yet proved at Singapore).

Of Alcyonaceans (2):—

Synalpheus gravieri ?; *S. triunguiculatus* ?.

Of *Telesto* (1):—

Synalpheus iphinoe.

Of sea-anemones (2):—

Hippolysmata prima ?; *Periclimenes brevicarpalis.*

Of corals (11):—

Alpheus ventrosus; A. splendidus; A. paralcyone ?; *Palaemonella vestigialis* ?; *Periclimenes parvus* ?; *P. spiniferus; P. amymone* ?; *P.* cf. *lutescens; Philarius imperialis; Harpiliopsis beaupresi; Coralliocaris graminea.*

Of crinoids (4 to 5):—

Synalpheus amboinae ?; ? *S. comatularum; S. stimpsoni; S. quadrispinosus* ?; *Palaemonella pottsi.*

Of *Pinna* (2):—

Anchistus custos; Conchodytes monodactylus.

Of *Tridacna* (1):—

Anchistus miersi.

General comments

The most striking feature of this list is the absence of deep-water species and the rarity of those species, such as *Heterocarpoides levicarina,* which are characteristic of intermediate depths. This is easily explained by the absence of truly deepwater in the area, and the very restricted area of water lying over deep pockets of the continental shelf.

The absence or rarity of a considerable number of widespread, and generally common, littoral species is more surprising. Most of these species also appear to be absent from the whole of the area of shallow seas extending from Siam to Sumatra, Java, and

Borneo. Several are present on the western coast of Sumatra, the southern coast of Java, and the eastern coast of Borneo. When the general distribution of such species are considered it becomes clear that many of them have a distinctly oceanic distribution. Such species include all members of the small families Rhynchocinetidae and Gnathophyllidae, a number of species of Hippolytidae (noted under that family), and several freshwater prawns such as *Atya pilipes, Caridina typus, Macrobrachium australe, M. lar,* and *M. latimanus*. Doubtless many members of the families Alpheidae and Pontoniinae are similarly restricted; but the distributions of members of these groups are less well-known.

The Singapore list does include a number of species which have previously been considered to be rare; but which are common in the Singapore area. In addition there are a number of undescribed species, mostly small forms with specialized habitats. The majority of these species which are common at Singapore and apparently rare elsewhere are forms which are liable to be overlooked in general collecting. When these are removed there are few species left which can be claimed to be non-oceanic in the sense of being absent or rare in oceanic areas. These are mostly freshwater of brackishwater species such as: *Caridina propinqua; C. tonkinensis; Macrobrachium trompi, M. lanchesteri, M. pilimanus,* and *M. geron*. There are very few marine species which apparently have this sort of distribution. These include *Mimocaris heterocarpoides* and *Hippolysmata ensirostris*.

Thus the Caridean and Stenopodidean fauna of Singapore is a rather depauperate version of the general Indo-West Pacific fauna. This phenomenon agrees with experience of the faunas of shallow enclosed seas in other parts of the world. The depauperization is most clearly revealed by the coral-reef association. Though there are many coral-reefs in the area there is good reason to believe that conditions are not ideal for the full development of the coral-reef assemblage. Coral-reefs disappear to the north-west of Singapore and are absent throughout much of the Straits of Malacca. Many coral-reef organisms belonging to groups other than the crustacea are either absent or very rare on Singapore reefs. Whilst this depauperization of the coral-reef assemblage is probably the result of a complex of factors the most important single factor is probably the low salinity of the local seas.

Detailed comparison of the Singapore fauna with that of other areas is difficult because no other Indo-West Pacific area of comparable size is so well-known. The fauna of comparable localities from other regions is inevitably much smaller, since these regions are much poorer in species than the Indo-West Pacific. Table 1 gives a comparative tabulation of the non-freshwater species of Singapore with those of the Moluccas and the Andamans. Both of these areas are larger than the Singapore area so that the wider coverage to some extent balances out the lesser intensity of collection. It is probable that many of the differences between the three lists represent collecting accidents; but others are real. In the Mollucan list there are more oceanic, and especially coral-dwelling species than at Singapore. The Alpheidae and Pontoniinae are much better represented there. The Andamans records include Kemp's extensive collections from the very well-developed littoral weed-beds and muddy areas around Port Blair. As at Singapore the weed-bed fauna is well-represented and includes some forms, such as *Phycocaris simulans* and *Paralatreutes bicornis* which have not been found at Singapore. Another striking feature of the Andaman list is the large variety of Crangonids, presumably associated with the muddy bottom of many of the seas collected. The three lists have much

in common and should probably be regarded as representing different facies of the same association. Viewed in this light the Singapore facies seems to represent the basic association, lacking the divergent specializations of the two other facies.

Certain generalizations are possible concerning the detailed local distribution of Singapore Caridea and Stenopodidea. In contrast to the Penaeidea and the Brachyura, the Caridea are almost equally well represented in variety of species on the shore and in offshore waters. There is no striking predominance of offshore species. Whilst several species are confined either to offshore or littoral waters there are a considerable number of species which are known from both types of habitat.

In both littoral and offshore areas the hard bottomed areas have a very much richer association than is found on soft-bottomed areas. Excluding the weed-bed species whose presence is controlled by the nature of the vegetation rather than that of the substrate, there are only about 17 marine species which have been found on soft bottoms. Two of these, *Anchistus custos* and *Conchodytes monodactylus* are commensals, whilst *Lysmatella prima* may also be a commensal. *Palaemon semmelinki* and *Macrobrachium equidens* are more characteristically brackish water forms. *Alpheus audouini* is more usually found on hard bottoms. This leaves only about 12 fully marine, free-living species which are characteristic of soft bottoms. This distribution contrasts strongly with that of the local Penaeidea, which are both more abundant and more varied on soft bottoms than they are on hard bottoms. The vast preponderance of hard-bottom species amongst the local Caridea is due to the abundance and variety of small crevice dwelling forms, especially in the family Alpheidae.

The Singapore caridean association agrees with those of other tropical areas in showing a great abundance and variety of Alpheidae and to a lesser extent Pontoniinae. By contrast the Pandalidae and marine Palaemoninae, together with the Spirontocaris group of the Hippolytidae are poorly represented as compared with cold-water regions.

Key to the genera of Malayan Caridea

The following key is adapted from Holthuis (1955). Genera which are unlikely to occur in Malayan waters or which are unlikely to be collected in depths of less than 100 metres have been omitted. Genera which have not yet been found in Malaya are marked with a + sign.

Caridean prawns are distinguished from all other prawns by a combination of characters of which the most easily observed are those shown by the abdomen, the thoracic legs, and the gills. In the Caridea the 2nd abdominal segment overlaps both the 1st and 3rd segments. This usually results in a characteristic humping of the abdomen. The 1st and 2nd walking legs are variously developed; but, in contrast to the Stenopodidea and Penaeidea the 3rd pereiopods are always simple and non-chelate. The gills are phyllobranchiate and are comparatively few in number as compared with those of the family Penaeidae.

The major groupings within the Caridea are not as yet firmly established. The superfamilies recognized by Holthuis (1955) differ considerably from those recognized by Borradaille (1907) and Balss (1927). Holthuis's treatment seems to represent a definite advance; but it is still somewhat unsatisfactory. Thus Holthuis still places the Atyidae in the Oplophoroidea, though they have little in common with the more typical members of that superfamily, beyond the retention of a few primitive characters which

were presumably common to the ancestors of all Caridea. Again Holthuis's new superfamily, the Bresiloidea, in which he includes the Rhynchocinetidae, seems to me to be a most unnatural grouping. In these circumstances I have felt it best to abandon all superfamily groupings for the purposes of this key.

The key is frankly artificial and is only safely usable for littoral prawns in the Indo-Pacific area.

1 (10). Carpus of 2nd pereiopods divided into two to many sub-joints or annuli ..... 2.
2 (3). First pereiopods stouter (except in *Ogyrides*), though often shorter, than the second pereiopods; at least one of the first pereiopods with a well-developed chela .... 4.
3 (2). First pereiopods slender, simple or with only a minute chela ..... *Pandalidae.*
4 (5). Only one of the first pereiopods chelate, the other being simple ..... *Processidae.*
5 (4). Both first pereiopods chelate ..... 6.
6 (7). Eye-stalks slender and very elongate, almost attaining the end of the antennular peduncle; rostrum reduced; first pereiopods feeble ..... + *Ogyrididae.*
7 (6). Not showing this combination of features ..... 8.
8 (9). Carpus of second pereiopods with 2 to many, but never 5 or 4, annuli; eyes free and not covered by carapace; first pereiopods usually not greatly enlarged; fingers of first pereiopods usually with dark tips; dactylus of first pereiopods never hammer-shaped ..... *Hippolytidae.*
9 (8). Carpus of second pereiopods with 5 or more rarely 4 annuli; eyes partly or wholly covered by carapace; first pereiopods usually greatly enlarged and massively built; fingers of first pereiopods rarely with dark tips; dactylus of first pereiopods often hammer-shaped ..... *Alpheidae.*
♂ 10 (1). Carpus of second pereiopods not subdivided into annuli ..... 11.
11 (12, 13). First pereiopods simple ..... *Thalassocaridae.*
12 (11, 13). First pereiopods subchelate ..... *Crangonidae.*
♂ 13 (11, 12). First pereiopods chelate ..... 14.
14 (15). Rostrum movable ..... *Rhynchocinetidae.*
♂ 15 (14). Rostrum not movable ..... 16.
♂ 16 (17). Fingers of chelae terminating in conspicuous brushes of long stiff hairs .... *Atyidae.*
17 (16). Fingers of chelae hairy or not but never terminating in hair-brushes of this type .. 18.
18 (19). First and second pereiopods subequal, with pectinate cutting edges; posterior pereiopods with exopods ..... *Pasiphaeidae.*
19 (18). Second pereiopods larger than the first, the fingers not usually pectinate; posterior pereiopods lack exopods ..... 20.
20 (21). Third maxillipedes expanded, leaf-like ..... + *Gnathophyllidae.*
21 (20). Third maxillipedes not expanded and leaf-like ..... *Palaemonidae.*

Family Pasiphaeidae

Leptochela is the only Malayan genus. This is represented by *L. robusta* a minute, planktonic form with reduced rostrum, which cannot well be confused with any other species.

Family Atyidae

1 (2). First and second pereiopods equal or subequal with the chelae cleft to or almost to the base, and the carpus short and deeply excavated ..... *Atya.*
2 (1). First and second pereiopods differing both in size and structure; chelae less deeply cleft; carpus of the second pereiopods elongate and not or scarcely excavated .. *Caridina.*

Family Rhynchocinetidae

The genus +*Rhynchocinetes* is not as yet known from Malaya, but may yet be found there.

Family Pandalidae

1 (4). Carpus of second pereiopods multiarticulate ..... 2.

2 (3). Carapace without lateral keels. Carpus of second pereiopods with more than 6 sub-joints; last three pairs of pereiopods very long and slender ..... *Plesionika.*

3 (2). Carapace with pronounced lateral keels. Carpus of second pereiopods with 6 sub-joints; last three pairs of pereiopods not excessively elongate ..... *Heterocarpoides.*

4 (1). Carpus of second pereiopods with 2 or 3 sub-joints ..... 5.

5 (6). Carpus of second pereiopods 3-jointed; the first four pairs of pereiopods with epipodites; heavy bodied, with short rostrum bearing many teeth ..... *Chlorotocoides.*

6 (5). Carpus of second pereiopods 2-jointed none of the pereiopods with epipodites; very slender, with long rostrum the larger portion of which is devoid of teeth *Chlorotocella.*

Family Thalassocaridae

Thalassocaris is the only genus in this family.

Family Palaemonidae

Only two of the four sub-families recognized by Holthuis, the Palaemoninae and the Pontoniinae, are known from or likely to occur in Malayan waters. The distinction between these two sub-families is by no means clear cut when the more primitive members are considered. *Leander urocaridella* which Holthuis includes in the Palaemoninae could almost as well be included in the Pontoniinae to which sub-family it was assigned by the original describer.

1 (18). With a pleurobranch at the base of the third maxillipede; posterior margin of telson armed with 2 pairs of spines and 2 or more pairs of setae (in primitive forms one of these can be considered as a spine or a setae with equal propriety); never commensal; Malayan forms never possessing a supra-orbital spine .... *Palaemoninae* 2.

2 (3). Carapace lacks an antero-lateral spine ..... *Leptocarpus.*

3 (2). Carapace with an antero-lateral spine ..... 4.

4 (7). Carapace with the antero-lateral spine in the hepatic region, well removed from the anterior carapace margin, except in very young individuals of certain species .... 5.

5 (6). Dactyli of last 3 pairs of pereiopods biunguiculate ..... *Brachycarpus.*

6 (5). Dactyli of last three pairs of pereiopods uniunguiculate ..... *Macrobrachium.*

7 (4). Carapace with the antero-lateral spine in the branchiostegal region, on or almost on the anterior margin of the carapace and below the pterygostomial line, where this is present ..... 8.

8 (15). Propodus of fifth pereiopod with transverse rows of short setae on its posterior margin; almost always with a well-defined pterygostomial line; first pleopod of male with *appendix interna* absent or rudimentary; setae of posterior margine of telson slender and never spiniform ..... *Palaemon*[1] 9.

9 (10). Mandibular palp 2-jointed ..... s.g. *Palaeander.*

10 (9). Mandibular palp 3-jointed ..... 11.

11 (12). Rostrum with an elevated basal crest; pleurae of fifth abdominal segment broadly rounded ..... 13.

12 (11). Rostrum lacking such a crest; pleurae of fifth abdominal segment usually pointed s.g. *Palaemon.*

13 (14). With a well-marked pterygostomial line; dactyli of last three pairs of pereiopods not excessivelv elongated ..... s.g. *Exopalaemon.*

1. The genus *Palaemonetes,* which is not likely to be encountered in Malaya, differs from *Palaemon* in lacking a mandibular palp.

14 (13). No pterygostomial line: dactyli of last three pairs of pereiopods longer than the combined lengths of the carpi and propodi of their respective legs
s.g. + *Nematopalaemon.*

15 (8). Propodus of the fifth pereiopod without these hair rows; no pterygostomial line; first pleopod of male with a well-developed *appendix interna;* one pair of the setae of the posterior margin of the telson is stout and often spine-like ..... 16.

16 (17). Mandible without palp; median setae of posterior margin of telson not markedly spiniform; in brackish or polyhaline waters ..... *Leandrites.*

17 (16). Mandibular palp well-developed; median setae of posterior margin of telson very stout and more or less markedly spiniform; marine ..... *Leander.*

18 (1). No pleurobranch at the base of the third maxillipede; posterior margin of telson with three pairs of spines (except in *Anchistioides* which has only two pairs)
Pontoniinae 19.

19 (22). Mandible with palp ..... 20.

20 (21). With hepatic spines ..... *Palaemonella.*

21 (20). Without hepatic spines ..... + *Vir.*

22 (19). Mandible without palp ..... 23.

23 (56). Third maxillipedes with exopods ..... 24.

24 (25). Dactyli of last three pairs of pereiopods with a distinct basal protuberance which remains visible when the dactylus is flexed on the propodus ..... 50.

25 (24). Dactyli of last three pairs of pereiopods without such a protuberance or with a protuberance which disappears into a slit in the propodus when the dactylus is flexed .. 26.

26 (45). Pleurae of first five abdominal segments broadly rounded or at most bluntly pointed . 27.

27 (32). Hepatic spines present ..... 28.

28 (29). Hepatic spines movable ..... + *Paranchistus.*

29 (28). Hepatic spines not movable ..... *Periclimenes* 30.

30 (31). Dactyli of last three pairs of pereiopods biunguiculate ..... s.g. *Periclimens*[2].

31 (30). Dactyli of last three pairs of pereiopods uniunguiculate ..... s.g. *Harpilius*[2].

32 (27). Hepatic spines absent ..... 33.

33 (40). Rostrum compressed and usually armed with teeth ..... 34.

34 (35). Second pereiopods very unequal in size and differing in shape; large chela *Alpheus*-like with the dactylus provided with a large, basal, molar-like tooth which fits into a cavity in the inner surface of the fixed finger ..... *Periclimenaeus.*

35 (34). Second pereiopods equal or unequal in size but similar in shape; no such specialized armature of the fingers ..... 36.

36 (37). Rostrum very short and not reaching beyond the eyes, without or with very few teeth; chela of second pereiopod high and somewhat compressed, the fingers provided with 2 or 3 teeth ..... + *Onycocaris.*

37 (36). Rostrum reaching distinctly beyond the eyes and usually toothed; chela of second pereiopods cylindrical and somewhat swollen, with the fingers provided with numerous denticles ..... 38.

38 (39). Tooth of the antennal scale not reaching beyond the end of the broad, oval lamella; rostral teeth sometimes absent, when present minute and placed near to the apex of the rostrum ..... *Anchistus.*

39 (38). Tooth of the antennal scale reaches beyond the end of the slender lamella; rostrum with large teeth along the whole of the dorsal margin ..... *Philarius.*

40 (33). Rostrum depressed or cylindrical and usually without teeth ..... 41.

41 (42). Outer margin of exopod of the uropods ends in 2 spines, the inner of which is movable ..... + *Pontoniopsis.*

42 (41). Outer margin of exopod of the uropods ends in a single non-movable spine ..... 43.

43 (44). Body not strongly depressed; dactyli of last three pairs of pereiopods not strongly curved and generally with one or more accessory teeth ..... + *Pontonia.*

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2. These must be regarded as units of convenience only; they are almost certainly not natural sub-genera.

44 (43). Body very strongly depressed; dactyli of last three pairs of pereiopods simple and strongly curved ..... + *Platycaris.*

45 (26). Pleurae of at least the fourth and fifth abdominal segments produced into a distinct, sharp point ..... 46.

46 (47). Body clumsily built but not depressed; carapace and abdomen areolated; lower margin of rostrum entire; third abdominal pleurae pointed ..... + *Dasycaris.*

47 (46). Body strongly depressed; carapace and abdomen smooth; lower margin of rostrum toothed; third abdominal pleurae rounded ..... + *Harpiliopsis.*

48 (51). Body strongly depressed; basal protuberance of last three pairs of pereiopods hoof-like; rostrum usually toothed ..... 49.

49 (50). No hepatic spine; second pereiopods not differing greatly in shape though sometimes differing in size ..... + *Coralliocaris.*

50 (49). With an hepatic spine; second pereiopods differing greatly both in shape and size + *Jocaste.*

51 (48). Body clumsily built but not strongly depressed; basal protuberance of last three pairs of pereiopods not hoof-like; rostrum often without teeth ..... 52.

52 (53). Antennal spine absent; rostrum depressed and toothless ..... *Conchodytes.*

53 (52). Antennal spine present; rostrum compressed, with or without teeth ..... 53.

54 (55). Rostrum toothless; basal protuberance of dactyli of last three pairs of pereiopods rounded and smooth ..... + *Dasella.*

55 (54). Rostrum toothed; basal protuberance of dactyli of last three pairs of legs pointed and covered ventrally with small scales ..... + *Cavicheles.*

56 (23). Third maxillipedes without exopods ..... 57.

57 (58). Hepatic spine present; dactyli of second pereiopods much longer than fixed fingers and hook-shaped ..... + *Hamodactylus.*

58 (57). Hepatic spine absent; dactyli of second pereiopods normal in shape and size ..... 58.

59 (60). Second maxillipedes with well-developed exopods; rostrum compressed; posterior margin of telson bears only 2 pairs of spines ..... + *Anchistioides.*

60 (59). Second maxillipedes without exopods: rostrum depressed basally; posterior margin of telson with 3 pairs of spines ..... + *Pontonides.*

Since many Pontoniinae are commensals the following summary of normal associations will be of value in determination of Pontoniine genera.

Free-living: *Palaemonella; Vir; Periclimenes; Anchistioides.*

With sea-anemones: *Periclimenes.*

With corals: *Palaemonella; Periclimenes; Periclimenaeus; Onycocaris; Philarius; Platycaris; Harpiliopsis; Coralliocaris; Jocasta.*

With sponges: *Periclimenaeus.*

With bivalves: *Paranchistus; Anchistus; Pontonia; Conchodytes; Pontonides.*

With crinoids: *Palaemonella; Pontoniopsis.*

With tunicates: *Periclimenaeus; Dasycaris; Dasella.*

Family Hippolytidae

1 (2). A movable tooth-like process at the base of the uropod; arthrobranchs present at the bases of the first four pairs of pereiopods ..... *Saron.*

2 (1). No such process; no arthrobranchs at the bases of the first four pereiopods ..... 3.

3 (4:5). Carpus of the second pereiopods 2 or 3-jointed ..... 6.

4 (3:5). Carpus of the second pereiopods 6 or 7-jointed ..... 16.

5 (3:4). Carpus of the second pereiopods with more than 7 subdivisions ..... 20.

6 (7). Carpus of the second pereiopods 2-jointed; endopodites of the second to fifth pleopods greatly enlarged and lamelliform ..... + *Phycocaris.*

7 (6). Carpus of the second pereiopods 3-jointed; endopodites of the pleopods normal .... 8.

8 (9). Dactyli of the last three pairs of pereiopods armed with a cluster of large teeth; outer margin of antennal scale armed with small movable teeth; superficially resembling a cirolanid Isopod in life ..... *Gelastocaris.*

9 (8). Dactyli of the last three pairs of pereiopods normal in shape and armature; no such teeth on antennal scale; not isopod-like in life ..... 10.

10 (11). With a supra-orbital spine; mandible with an incisor process ..... *Hippolyte.*

11 (10). No supra-orbital spine; mandible without incisor process ..... 12.

12 (13). Antero-lateral angle of carapace entire; rostrum very elongate and ensiform; (third maxillipedes lack exopods) ..... *Tozeuma.*

13 (12). Antero-lateral angle of carapace armed with a series of small teeth; rostrum relatively short and deep ..... 14.

14 (15). Third maxillipedes possess exopods ..... *Latreutes.*

15 (14). Third maxillipedes lack exopods ..... + *Paralatreutes.*

16 (17). Upper part of third segment of antennular peduncle bearing a broad, movable plate; mandible without palp ..... *Thor.*

17 (16). This segment without such a plate; mandible with a palp ..... 18.

18 (19). Supra-orbital spine present; mandibular palp 3-jointed ..... + *Alope.*

19 (18). No supra-orbital spine; mandibular palp 2-jointed ..... + *Heptacarpus.*

20 (21). Carapace with prominent longitudinal carinae; abdominal segments with large, mid-dorsal, posterior spines; pleurae of abdominal segments ending in 1 or 2 sharp points ..... *Mimocaris.*

21 (20). Carapace lacks these carinae; no such mid-dorsal, abdominal spines; abdominal pleurae rounded ..... 22.

22 (23). Third maxillipedes without exopods ..... + *Merguia.*

23 (22). Third maxillipedes with exopods ..... *Hippolysmata*[3] 24.

24 (25). Rostrum longer than carapace and with a basal crest of closely set teeth s.g. *Exhippolysmata.*

25 (24). Rostrum shorter than the carapace and lacking such a crest ..... 26.

26 (27). Bases of pereiopods lack epipodites ..... s.g. *Lysmatella.*

27 (26). Bases of the first four pereiopods provided with epipodites ..... s.g. *Hippolysmata.*

Family Alpheidae

The key to this family is adapted from that of Holthuis (1955) by the exclusion of all genera which have not been reported from the Indo-Australian area.

1 (2). Carpus of the second pereiopods 4-jointed ..... + *Arete*[5].

2 (1). Carpus of the second pereiopods 5-jointed ..... 3.

3 (10). With a movable plate articulated to the postero-lateral angle of the 6th abdominal segment ..... 4.

4 (5). Rostrum absent or indistinct ..... + *Betaeus.*

5 (4). Rostrum prominent ..... 6.

6 (7). Rostrum round at the tip in lateral view and with a broad vertical lamella + *Aretopsis.*

7 (6). Rostrum slender and pointed at the tip in lateral view ..... 8.

8 (9). Eyes almost completely concealed in dorsal view; first pereiopods with arthrobranches at their bases ..... + *Alpheopsis.*

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3. The closely allied genus *Lysmata*, which is not likely to be found in Malayan waters, can be distinguished by the bifid, upper antennular flagellum.

9 (8). Eyes partially exposed in dorsal view; first pereiopods without arthrobranches *Athanas*[5].

10 (11). Dactylus of large second leg with a large molar tooth which fits into a cavity in the fixed finger ..... 14.

11 (10). Dactylus of large second leg lacks such a tooth ..... 12.

12 (13). Eyes completely exposed in dorsal view. Rostrum absent or rudimentary + *Automate*.

13 (12). Eyes almost completely covered in dorsal view; rostrum well-developed and reaching far beyond the end of the eye-stalks ..... *Salmoneus*.

14 (15). The first four pairs of pereiopods bear epipodites ..... *Alpheus*.

15 (14). None of the pereiopods bear epipodites ..... *Synalpheus*.

Family Ogyrididae

This family contains only the genus +*Ogyrides*, which has not yet been reported from Malaya.

Family Processidae

1 (2). The first pereiopods bear exopods ..... *Nikoides*.

2 (1). The first pereiopods lack exopods ..... *Processa*.

Family Gnathophyllidae

No genera of this family are known from Malaya but three are included here since they may yet be found in Malayan waters.

1 (2). Outer antennular flagellum deformed by the extreme broadening of most of its joints into a broad, flat, leaf-like appendage; chelae of second pereiopods also flattened and leaf-like ..... + *Hymenocera*.

2 (1). Outer antennular flagellum normal; chelae of 2nd legs not leaf-like ..... 3.

3 (4). Chelae of second pereiopods broad and flattened, though not leaf-like; last 2 joints of the third maxillipede almost as broad as the antepenultimate joint; outer margin of dactylus of second pereiopods serrated ..... + *Phylloganthia*.

4 (3). Chelae of second pereiopods not greatly broadened or flattened; last two joints of third maxillippede less than half as broad as the antepenultimate joint; outer margin of dactylus of second pereiopod not serrated ..... + *Gnathophyllum*.

Family Crangonidae

The genus *Crangon* Fabricius, 1798 is included in the key because of Kemp's record of a variety of *C. vulgaris* from Akyab (Kemp, 1916). *C. vulgaris* is a common European species and there are no other records of any member of this genus from anywhere in the Indo-Pacific region. Kemp's record is therefore very surprising; but Kemp was a very careful worker and there are no positive grounds for disputing his conclusion. In these circumstances one must accept the possibility that *Crangon* may be found in Malaya, though this possibility seems to be very remote.

1 (2). Second pereiopods almost equal in length to the succeeding pereiopods .. + *Crangon*.

2 (1). Second pereiopods much shorter than the succeeding pereiopods ..... 3.

3 (4). With 6 or 7 gills on each side of the body, each with its apex directed backwards *Pontophilus*.

4 (3). With 8 gills on each side of the body, each with its apex directed forwards *Pontocaris*.

5. Since this paper went into press, I have been able to consult the important paper of Banner, A. H. & Banner, D. M. (1960), Contributions to the Knowledge of the Alpheid Shrimps of the Pacific Ocean Part V. Members of the genus *Athanas*., *Pacific Sci*., **14**, 129–155. As a result I am now convinced that *Arete* and *Athanas* cannot be maintained as distinct genera.

TABLE 1

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans[4]	Moluccas	Remarks
Leptochela robusta ..	*	..	*	Planktonic
Heterocarpoides levicarina ..	*	..	*	Rare species
Chlorotocella gracilis ..	*	*	*	
Chlorotocoides spinicauda ..	*	*	*	
Saron marmoratus ..	*	*	*	Rare at Singapore
neglectus	*	*	*	Rare at Singapore
Ligur uveae	..	..	*	Rare species
Thor maldivensis ..	..	*	*	
paschalis	*	*	*	Very rare at Singapore
amboinensis ..	..	*	*	
intermedius ..	..	..	*	Very rare species
Hippolyte ventricosa ..	*	*	*	
commensalis ..	..	*	..	Very rare species
Phycocaris simulans ..	..	*	..	Very rare species
Paralatreutes bicornis ..	..	*	..	Very rare species
Latreutes mucronatus ..	*	*	..	
porcinus ..	*	*	..	Common where found at all
pygmaeus ..	*	*	..	
Tozeuma armatum ..	..	*	*	
lanceolatum ..	*	..	..	Replaces *T. armatum* at Singapore
Gelastocaris paronae ..	*	*	..	
Mimocaris heterocarpoides ..	*	..	..	Rare, Malaysian
Lysmata dentata ..	..	..	*	
trisetacea ..	..	..	*	
Hippolysmata amboinensis ..	..	..	*	Rare species
kukenthali ..	..	..	*	
vittata ..	*	*	*	
prima ..	*	*	..	
ensirostris ..	*	..	..	Common where found
Athanas monoceros ..	*	..	..	
parvus	*	..	..	
jedanensis ..	*	..	*	

4. The Alpheidae of the Andamans are very incompletely known and so have been omitted.

TABLE 1—*continued*

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans[4]	Moluccas	Remarks
Salmoneus hilarulus ..	*	..	*	
Arete amboinensis ..	..	..	*	
iphianassa ..	..	..	*	
Synalpheus amboinae ..	*	..	*	
comatularum ..	*	..	*	
stimpsoni ..	*	..	*	
carinatus ..	..	..	*	
neomeris ..	*	..	*	
gravieri ..	*	..	*	
iphinoe ..	*	..	*	
jedanensis ..	*	..	..	
streptodactylus ..	..	..	*	
modestus ..	..	..	*	
iocasta ..	..	..	*	
paraneomeris ..	..	..	*	
nilandensis ..	..	..	*	
fossor ..	..	..	*	
triunguiculatus ..	*	..	..	
stormi ..	*	..	..	
demani ..	..	..	*	
tumidomanus ..	*	..	..	
hastilicrassus ..	..	..	*	
acanthitelsonis ..	*	..	*	
hilarulus ..	*	..	*	
exilipes ..	*	..	*	
amabilis ..	..	..	*	
bituberculatus ..	*	..	*	
bispinosus ..	..	..	*	
quadrispinosus ..	*	..	*	
neptunus ..	*	..	*	Very rare at Singapore
theano ..	*	..	*	
pescadorensis ..	*	..	..	
sp. (*laevimanus* group) ..	*	..	..	
Alpheus hailstonei ..	..	..	*	
collumnianus ..	..	..	*	
acutofemoratus ..	..	..	*	
ventrosus ..	*	..	*	

4. The Alpheidae of the Andamans are very incompletely known and so have been omitted.

TABLE 1—*continued*

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans[4]	Moluccas	Remarks
Alpheus splendidus ..	*	..	..	
macrochirus ..	..	..	*	
lutini	*	..	..	Rare species
malleodigitus ..	..	..	*	Found in Malaya
alcyone ..	..	..	*	
paralcyone ..	*	..	*	
spongiarum ..	*	..	*	
eulimene ..	..	..	*	
pachychirus ..	..	..	*	
stanleyi ..	*	..	*	
frontalis ..	..	..	*	
bidens	..	..	*	
praedator ..	..	..	*	
insignis	..	..	*	
philoctetes ..	..	..	*	
cf. *lanceloti* ..	*	..	..	
gracilipes ..	..	..	*	
bengalensis ..	*	..	..	
alpheopsides ..	*	..	..	
rapax	*	..	..	Abundant at Singapore
angustidigitus ..	*	..	..	
distinguendus ..	*	..	..	
rapacida ..	*	..	..	
pubescens ..	..	..	*	
miersi	..	..	*	
bisincisus ..	*	..	..	
microrhynchus ..	*	..	..	
audouini ..	*	..	*	
chiragricus ..	*	..	*	
crassimanus ..	*	..	*	
pareuchirus ..	*	..	*	
polyxo	..	..	*	
strenuus ..	..	..	*	Occurs at Penang
cf. *leptochirus* ..	*	..	..	
cf. *maindroni* ..	*	..	..	
pacificus ..	..	..	*	
parvirostris ..	*	..	*	
hippothoe ..	*	..	*	
euchirus ..	*	..	*	

4. The Alpheidae of the Andamans are very incompletely known and so have been omitted.

TABLE 1—*continued*

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans[4]	Moluccas	Remarks
Alpheus funafutensis	..	..	*	
edamensis	..	..	*	Rare species
Gnathophyllum fasciolatum	..	..	*	
Hymenocera elegans	..	..	*	
Leander tenuicornis	*	*	*	
urocaridella	*	*	..	
Leandrites deschampsi	*	..	..	Common at Singapore
Palaemon concinnus	..	..	*	
debilis	..	..	*	
serrifer	*	..	..	Not known from east of Madura
semmelinki	*	..	..	
Macrobrachium equidens	*	..	*	
Palaemonella lata	..	*	..	
vestigialis	*	*	*	
pottsi	*	..	..	Possibly only a form of *P. vestigialis*
tenuipes	..	..	*	
affinis	..	..	*	
Vir orientalis ..	..	..	*	*
Periclimenes aesopius	*	..	*	
impar	..	*	..	Rare species
parvus	*	..	..	Rare species
ceratophthalmus	..	..	*	Rare species
signatus	..	*	..	Rare species
agag	..	*	..	Rare species
amboinensis	..	..	*	Rare species
amymone	*	..	*	
andamensis	..	*	..	Rare species
brevicarpalis	*	*	*	
brocki	*	..	*	
calmani	*	*	..	
digitalis	..	*	..	Rare species

4. The Alpheidae of the Andamans are very incompletely known and so have been omitted.

TABLE 1—*continued*

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans	Moluccas	Remarks
Periclimenes sp. nr. *digitalis*	*	..	..	Rare species
elegans ..	*	*	*	Rare at Singapore
galene ..	..	..	*	Rare species
grandis ..	*	..	..	
inornatus ..	..	*	..	Rare species
lutescens ..	*(?)	..	*	
platycheles ..	..	..	*	Rare species
proximus ..	..	*	..	Rare species
psamathe ..	..	..	*	
seychellensis ..	*	*	*	
sibogae ..	..	..	*	Rare species
spiniferus ..	*	*	*	
suvadivensis ..	*	..	..	
tenuipes ..	..	*	*	Occurs in Malaya
Paranchistus biunguiculatus ..	..	..	*	Papuasian
Anchistus custos ..	*	*	..	
demani ..	..	*	..	Rare species
miersi	*	*	..	
Thaumastocaris streptopus ..	..	..	*	Rare species
Periclimenaeus minutus ..	..	..	*	Rare species
rhodope ..	..	..	*	
tridentatus ..	*	..	..	
truncatus ..	..	..	*	Rare species
Philarius imperialis ..	*	..	*	
Pontonia katoi	..	..	*	
styliferus ..	..	..	*	Rare species
Harpiliopsis beaupresi ..	*	*	..	
depressus ..	..	*	*	
Coralliocaris graminea ..	*	*	*	
superba ..	..	*	*	
venusta ..	..	..	*	
Jocaste lucina	..	..	*	
Conchodytes biunguiculatus ..	..	*	*	
monodactylus ..	*	..	..	Rare species
tridacnae ..	..	*	*	

TABLE 1—*continued*

Comparative table of the Caridea and Stenopodidea of Singapore and two non-Malaysian, Indo-Pacific areas. Species only known from freshwater and/or brackish water habitats have been excluded.

Species	Singapore	Andamans	Moluccas	Remarks
Cavicheles kempi ..	..	..	*	Rare species
Hamodactylus boschmai ..	..	..	*	Rare species
Anchistioides compressus ..	..	*	..	
Pontophilus angustirostris ..	*	..	*	
parvirostris ..	(?)	..	..	
candidus ..	..	*	..	Rare species
incisus ..	..	*	..	Rare species
lowisi ..	..	*	..	Rare species
plebs ..	..	*	..	Rare species
sabsechota ..	..	*	..	Rare species
Pontocaris orientalis ..	*	*	..	
Stenopus hispidus ..	*	..	*	Rare at Singapore
tenuirostris ..	..	..	*	
Odontozona ensifera ..	..	..	*	Rare species

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LIST A

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LIST A—*continued.*

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Explanation of Plate 2

1. Map of Singapore Island and surrounding areas with localities of Caridea and Stenopodidea.

The Javanese Fishes described by Kuhl and van Hasselt

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(Received July, 1961)

IN DECEMBER 1820, Heinrich Kuhl and Jan Coenrad van Hasselt arrived in Java to begin their investigations on the natural history of the Dutch territories in the Far East. The results of their ichthyological studies were the subject of various letters from van Hasselt to C. J. Temminck who was then Director of the Rijksmuseum van Natuurlijke Historie in Leiden. Of these letters, there were two which are of some importance to systematic ichthyology. The first letter dated 29th October, 1822 which was subsequently published in two parts (van Hasselt, 1823a & 1823b), mentions or describes some 50 species of fishes. The published extract from the second letter dated 29th December, the same year (van Hasselt, 1823c), includes 28 species. Owing to the untimely death of these two scientists, no further ichthyological reports were forthcoming and information on the extensive collections that they made and the manuscript drawings they prepared, was made known only subsequently by Cuvier and Valenciennes in their volumes of *Histoire Naturelle des Poissons,* and later by Bleeker who obtained some of the manuscript drawings.

A brief list of the collections received in Leiden was given in a letter dated 3rd December, 1824 from Temminck to the Minister of Education (Veth, 1879, p. 37). In this the fishes were numbered as some 1,400 specimens of 420 species. The manuscript drawings were stated as being yet to follow. Most of these and other manuscripts arrived in Leiden on 24th December, 1825. In the same letter, Temminck pointed out that the fish collections would be described by Cuvier and Valenciennes for which purpose the latter had already arrived in Leiden at that time. Owing to the high cost of publishing, it had been also decided that these descriptions would be incorporated into the *Histoire Naturelle des Poissons* being prepared by these two authors.

A much altered version of the van Hasselt letters, translated from the published Dutch text, was given in the French language by de Ferrusac (van Hasselt 1824a and 1824b). A footnote to the first letter (Footnote (1), van Hasselt, 1824a, p. 91), amply indicates that most of these alterations were provided by Valenciennes, although it is very likely that the general translation was made by Dr. H. Boie. It is possible that the amendments that occur in this version of the second letter, could also be attributed to the same sources.

In September 1959, I was able to examine copies of the original published texts of these letters which were kindly provided by Dr. M. Boeseman of the Rijksmuseum van Natuurlijke Historie, Leiden. Dr. Boeseman and his colleague Mr. H. E. Muller rendered much assistance in the preparation of an English translation. This is reproduced below. Typographical errors and mis-spellings of names, evidently caused by the poor handwriting in the original letters, are all repeated exactly as they appear in the original printed version. The footnotes are my own. Most of the plates which are herein reproduced were photographed and sent to me through the kindness of Dr. E. Trewaves of the British Museum (Natural History), London. I am indebted to Dr. M. Boeseman for having read the manuscript of this paper and for his criticizms and advice.

Extract from a letter from Dr. J. C. van Hasselt, to Mr. C. J. Temminck. Algemeene Konst-en Letter-Bode, 1823, part I, No. 20, Friday 16th May, pp. 315-317.

I am now willing to fulfil what Kuhl promised in one of his letters, by making you acquainted with that which we together, and which after his death I was able to discover about the Ichthyology of Java. We had as yet visited no sea-beach before the decease of my friend[1]; my sojourn after that in Batavia is known to you; thus everything concerning the sea fishes has been done after Kuhl's death[2]; as concerns the river fishes this has mainly been done by us together. Already last July I sent a general report of my activities since the decease of my friend to his Exc. the Minister of Education[3] and in this are implied the general results of the Ichthyological discoveries. For you I have reserved to myself to give now the latter in further detail.

To pursue in this a Systematic sequence will be not unsuitable.

CHONDROPTERYGIENS.

Of the Family of the *Cyclostomes* Dum., I have nothing.

— —— ——— — —— *Plagiostomes* — 2 *Scyllia* Cuv., of which *one* is figured Seba III ? Tab. 34 No. 1 and which seems to me to distinguish itself sufficiently from the other related species and to which I have given the name *Quinquecornuatum*[4]; I have specimens of over 8 feet. To the *second* species I have given the name *Griseum*.

My *Carcharias Javanicus* approaches mostly *Meni Sauru,* which is in the Museum at Paris, and from which it differs however in the shape of the Pinna Caud; these 3 species have been figured under my eyes[5].

The *Zygaena* which is figured in Russel Tab. 12[6], and which according to Cuv. is the same as *Z. Zygaena,* seems to me to differ in the shape of the head and it would then deserve the name *Z. Indica*[7].

My *Z. Laytcephala* is totally different from the known species; I have both in drawings.

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The only *Pristis* which I have received has to be compared with the P. Cuspidata, Lath. L. Transact. T. 26 T. 3[8].

Rhinobatus laevis and *Thouini* I have manyfold and from the comparison it will be easy now to affirm or to disprove that which Cuv. believes about its identity (namely of the latter) with *Rh. Rhinobatus.*

Of *Rhina anchylostomus* Schn. I have only one specimen. The figure of Schn. is very correct.

1. Kuhl died 14th September, 1821.

2. With the exception of those species referred to Kuhl in these letters, information on the marine fishes accredited by Cuvier and Valenciennes to Kuhl or to both Kuhl and van Hasselt in their volumes of *Histoire Naturelle des Poissons* should accordingly be referred to the authority of van Hasselt alone.

3. Kuhl & van Hasselt, 1822.

4. Superseded by *Stegostoma tigrinum* (Forster), 1781, p. 24.

5. The artists commissioned to work with Kuhl and van Hasselt were Keultjes, van Raalten and Bik.

6. Russel, 1823, I, p. 8, pl. XII: Vizagapatam.

7. See Plate 3, figure 1.

8. Latham, 1794, p. 279, pl. 26, fig. 3.

Of *Torpedo Tuclei* Schn. I have 2 small specimens; this fish has never come into my hands than as already half putrified.

Of *Trygon* I have 5 species.

1. The *Wolgatzuke* of Russel Tab. 3.

I have had figured 4 others and of these one has to be compared with the *Lymnia* Cuv. Forskael p. 17[9]. The others distinguish themselves sufficiently from those thus far known.

The *first* species which I have of *Myliobatus* Dum, is a new one for which I consider the name *Cyclura* as characteristic. This one is figured; the second agrees much with Russel Tab. 8, designated by Kuhl by the name *Ocellatus*[10]; the form of my specimens has more resemblance to *R. Neruiari* Schn. than to this figure of Russel, the patches being similar to Russ. figure. The fear of the tail spine has been the reason why I could not get hold of an undamaged specimen from the fishermen, from which it would otherwise be easy to decide which of both should be my species, because *R. Nazinari* Schn. distinguishes itself so easily by 2 spines.

A scarce animal here is that which is found in Russel Tabula 6[11] or Schneider's *R. micrura*[12] which was placed by Kuhl, according to his papers as a special genus under the name *Gymnura*[13].

Cuv. cites Lacep. III, 5, Tab. 12 under the *Ceph. Cephaloptère*. Kuhl thought it to be identical with Russ. Tab. 9[14] and thus accepted a *C. Tatraniana*[15]. My specimens deviate solely from Russel's figure by a longer tail.

An animal close to though too much different in the main character of the Cephalopteres I have separated from the latter under the name *Rhenoptera;* this is figured too.

Of the GYMNODONTES I have 3 *Tetrodons,* of which one could be the *Lunaris* Schn., the others *Stellatus* Schn. and *Testudinius* Bl. The drawings of Bl. are too uncertain, especially regarding the colours, to make a decision on this.

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The *Stellatus* is Russel Tab. 18 which is found under that name in the Museum at Paris (according to Kuhl).

Regarding the poison of the *Tetrodons* this is sufficiently important to merit mention; see now what my researches have taught me.

The species mentioned here, known under the name *Bocutok,* are eaten only by the Chinese especially because only they know how to clean these of the poisonous matter and they unanimously say that only the *ovarium* possesses this harmful quality and that this being removed, the rest is consumed without fear by them. Such an *ovarium* thrown before a domestic animal causes it to die immediately after consumption.

How far this is in accordance with the truth experiments will soon prove to me. The paralytic condition of my arms did not permit this at that time.

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9. Forskal, 1775, p. 17.

10. Superseded by *Raja guttata* Shaw, 1804, p. 285, pl. 142 (on Russel, 1803, I, p. 5, pl. VIII): Indian and African Seas, Madagascar, Coromandel, Brazil.

11. *Raja poecilura* Shaw, 1804, p. 291 (on Russel, 1803, I, p. 4, pl. VI): Vizagapatam.

12. Bigelow & Schroeder (1953, p. 411), have distinguished *micrura* Bloch & Schneider from *poecilura* Shaw.

13. The Indo-Pacific species would consequently be referred to as *Gymnura poecilura* (Shaw).

14. *Mobula diabolus* (Shaw), 1804, p. 291 (on Russel, 1803, I, p. 5, pl. IX): Vizagapatam.

15. Kuhl was mistaken in considering the two as identical. Lacepede's figure (vol. V, pl. 20, fig. 3) is indicated with a tail spine.

Balistes lineatus and *Stellaris* Schn., which I have found here, are both eaten throughout the year by Chinese and Malays without fear or caution, so that at least these 2 species have even no periodic harmfulness.

Bloch Tab. 414, the *Balistes monoceros* var. a. Schneid, p. 463 and which Kuhl gave as an own species under the name *Al. laevis* and *Al. Javanica* of myself, are the only *Alutherae* I have.

The *Monacanthus Geographicus* of Perron is found in my collection and two others of which one is figured Seba T. ? Tab. 24 No. 18[18] and Gronov. Tab. 6 No. 191 F. 5[19], to which I gave the name *Sarothrura*[20] and a second not figured called *M. inornatus.*

Extract from a letter from Dr. J. C. van Hasselt, to Mr. C. J. Temminck. Algemeene Konst-en Letter-Bode, 1823, part I, No. 21, Friday 23rd May, pp. 329–331.

(Continuation and End from Page 317.)

Of the LOPHOBRANCHIES there lives in the rivers near Batavia a *Syngnathus,* which I have had figured, and have given the name *Fluviatilis.*

Of the SALMONS I have nothing but a *Saurus,* the same which is figured by Russ., Tab. 172[21]. This is known in the Museum at Paris under the name *S. foetens* according to annotations of Kuhl; to me it seems to be sufficiently distinguished from that by a shorter anal fin, and I have therefore given it the name *Carinatus*[22].

In the CLUPEAE the Indies yields more.

Of *Clupea Melostoma* Schneid. I have several specimens.

The Koelee (?) of Russ. Tab. 195 is here in large numbers, and to that must be added one which I have had figured and have given the name *Macrura.*

To *Megalops cyprinoides* Lacep. Bl. 403[23] must be added a second which has very great resemblance to *Meg. Naso* Lacep., but in the numerous specimens I have never been able to find a Filamentous dorsal fin. The form of the upper jaw differs so much from Clupea and Megalops, that I felt myself urged to propose a special genus name and I have chosen that of *Gonostoma* for the figure made of it.

The *Engraulis* figured by Russel, Tab. 187[24] differs from *E. Commersonii* by a dorsal fin which is situated nearly opposite the anal and not the ventral fin; the name *Indicus* would be not inappropriate[25].

Thrissa macrodon and *microdon* Cuv., *Natoptera Kapirat* Lacep. and *Elops Saurus* are in my collection; of this last genus I have one species which differs from the previous by a shorter upper jaw and by something strange to the *Elopes;* the Radii branchiostegi 14 in number while commonly 30 and more are found.

The sea which bathes Java has with that of Coromandel also *Chirocentrus dentex* in common.

I have both *Triacenthus biaculeatus* Cuv. and *Ostracion punctatus comm.*

(The Continuation and End hereafter).

18. Seba, 1758, III, p. 63, pl. 24, fig. 18.
19. Gronovius, 1763, p. 52, No. 191, pl. 6, fig. 5.
20. See Plate 4, figures 3 & 4.
21. Russel, 1803, II, p. 56, pl. CLXXII.
22. See Plate 5, figure 5.
23. Bloch, 1795, XI, p. 32, pl. 403.
24. Russel, 1803, II, p. 71, pl. CLXXXVII.
25. See Plate 6, figure 6.

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Russel figures in his 207th plate[26] an animal which I don't find cited; it belongs to the *Clupeae* of Cuv. but can be brought down to no genus. Owing to the form of the Membrana branchiostega which looks like having an opening I have accepted the genus name *Lutodeira* and have called the species *Indica*[27].

Anticipate before long from me in the same way a continuation concerning the fishes of these provinces; now first, the *Cyprines* living in the rivers here in fair numbers and which are not only new species, but nearly all new genera. ——— The species of these are totally different corresponding with different altitude of the terrain and thus they are by no means the same *Cyprines* which are found near Batavia and in the mountains.

The sojourn in the various regions and our altitude measurements there will show how high each species ascends in the rivers, or where it is found and ends.

The miserable condition in which I found myself during nearly the whole of my sojourn at Batavia has been the reason why I have only been able to perform few anatomical investigations. Soon however, I reach the south coast of Java and then I hope to be more fortunate.

From the things mentioned above you will have seen that I am at the moment on route, namely, in the interior of Bantam; I have had the luck to get some species of birds . . .[28].

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I solicit the favour of your protection and friendship.

(signed) J. C. v. Hasselt.

Lebuk the 29th October, 1822.

Extract from a letter from Dr. J. C. van Hasselt to Mr. C. J. Temminck, written from Tjecande, Residency of Bantam, on 29th December, 1822. Algemeene Konst-en Letter-Bode, 1823, part II, No. 35, Friday 29th August, pp. 130–133.

Continuation of my last letter sent in October 1822.

The Family Esoses has given me 2 species of *Belone, B. Coromandelica* Cuv., Russel, T.175 and one that is figured in Russel, Tab. 176[29] and for which the name *strongylura* would be appropriate[30].

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The *Hemiramphus* differs so much from Russel's Tab. 177 to which Cuv. has given the name H. Russelii, that if at least Russel's figure is exact it has without doubt to be distinguished from the latter. It still remains however to be compared with H. Marginatus, Cuv., Lacep. V, VII, 2 and with Russel's Tab. 178. In my collection it is included under the name Viridis?

26. Russel, 1803, II, p. 84, pl. CCVII.
27. See Plate 7, figure 7.
28. I have omitted this part of the letter since it contains no relevant ichthyological information.
29. Russel, 1803, II, p. 61, pl. CLXXVI.
30. See Plate 8, figure 8.

A *Hemiramphus* which is found in the brooks around Buitenzorg and nearly all over Java has already during the lifetime of Kuhl, been separated by us from that genus under the name *Dermogenys* because of the membranous extension occurring on either side of the maxillae. The species bears the name *Pusillus*, is called by the Javanese Joelong-Joelong and it has been figured by us[31].

The *Exocetus* which is found near Batavia comes nearest to the *Mesogaster*, bl.399[32] but differs in having a fewer number of dorsal fin rays. It is included under the name *Javanicus*.

A diminutive species which I caught in the rivers near Buitenzorg differs in general form and from the *Cyprines* and the *Esores* though agreeing with those in other respects. On the strength of the teeth which span the lower jaw externally and the entire upper jaw, I have placed it in the *Esores* and in fact under the genus name *Odontopsis* while the species can be called *Armata*. From the drawing made of it the very characteristic form will be sufficiently clear.

The family CYPRINACAE is abundant in Java as will become clear further on and there are some species already found by me still missing in this report.

Although the different rivers have always many species in common they often contain a few which are wholly their own and not found in the others; whilst in one and the same river the species also differ considerably in connection with the amount the bed rises above sea-level; and those are not at all the same species which are found in the muddy rivers near the beach and which are found in the clear streams of the mountains. There are some notes lacking at this moment for giving you the distribution of each

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species but for which I will have a better opportunity in future with the shipment.

A true *Cyprinus* Cuv. I did not find indigenous in Java until now; there lives in the ponds one which would have been brought over from China and which the Javanese call *Tambra Maas*. The same is figured under me[33] under the name *floripenna*.

Of the genus *Barbus* six species are figured.

B. *obtusirostris* Nobis Gengehek in Sundanese, near Buitenzorg.
rubripinna Mihi Batavia.
hypseconotus Mihi idem.
maculatus Nobis Bocutoir in Sundanese, Buitenzorg.
tambra Nobis Tambra in Mal. Buitenzorg.
striatus Mihi Tjelarkahan.
leuciseus Cuv. *lateristriatus* Nob. et. Tab nostra Tjitjaerae Bat. Parai in Sundanese, prope Buitenzorg.

The genus *Hampala* after the local name *Hampel* has been erected by us already during Kuhl's lifetime just as the next genera *Crostocheilus, Lobocheilus, Naunacheilus* while the genera *Diplocheilus, Labio-barbus, Homalophra, Oxygaster, Acantopsis, Acantophthalmus* have been accepted by me.

31. Although the description is far from adequate, the stated fact that the fish occurs in the brooks around Buitenzorg and nearly all over Java would sufficiently characterise the species. *D. pusillus* Kuhl & van Hasselt is as yet the only true fresh-water Hemiramphid known from Java.

32. Bloch, 1795, IX, p. 17, pl. 399.

33. Meaning, under my supervision.

The genus *Hampala* Nob. comes nearest to *Leuciseus* Cuv. but differs in having 2 filaments at each corner of the mouth; the species is figured under the name *Macrolepidota* Nob. and occurs near Buitenzorg.

The genus *Labiobarbus* Mihi consists of Labiones with 4 small barbels, with a single dorsal fin of which the second ray is not serrated and thus combines the characters of *Labio* and *barbus,* wherefore I adopted the name *Labiobarbus.* The names *L. Leptocheilus* M. and *Lipocheilus* M. distinguish the two species which were both found in the river near Batavia and figured under me.

Crossocheilus Nob. is a genus related to Leuciseus, distinguishes itself by a mouth opening directed downwards in the form of a parallelogram; the drawing bears the name *Oblongus* Nob.

Lobocheilus Nob. is too much distinguished by a totally different form of the mouth

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to be combined with any other genus; in our drawing it bears the name *Falcifer.*

The genus *Deplocheilus* Mihi, species *Erythropterus* Mihi *Mellung* in Sundanese, has been figured as well; it occurs near Buitenzorg, and though approaching *Labocheilus* most closely it however merits to represent an own genus by the own form of the mouth and maxillary bones.

Noemacheilus Nob. approaches by the flat maxillae the genus Poecilia Schn; the Sundanese call it *Jelaer;* it occurs near Buitenzorg and the species has in our drawing the name *fasciatus* Nob.

Cobitis Octocirrhus Tab. nostra, Irivroet in Sundanese, Kitjaerae has, in common with *Cobitis taenia* Linn. a moveable spine below the eye; this character seems to me to be as important as various characters in the genera of Cyprines erected by Cuv., and as a section of Cobitis would consequently deserve the name *Acantophthalmus.* The unusual structure of the air-bladder is exactly as that of the Cobites and it lives just like these in small brooks. To this *Acantophthalmus* I reckon another 2 species which distinguish themselves solely by a more backwardly placed dorsal fin. In the drawing they bear the names *fasciatus* and *Javanicus* Mihi both Rambockassang in the Sunda region.

A genus approaching these Acantophthalmus, to which I have given the name *Acantopsis* distinguishes itself from them by a very elongate pointed face which in those is blunt and so short that the eyes are situated nearly in a vertical line with the mouth-opening. Owing to this elongation the moveable spines are situated far in front of the eyes and the whole form too divergent (for them) to be combined with each other. I found this animal in the river at Batavia and in my drawing it bears the name *Dialuzona* Mihi[34].

The genus *Homaloptera* Mihi, distinguishes itself mainly by the horizontal position of the pectoral and abodminal fins as a consequence of which it somewhat attains the form of the Rhinobates. The species Javanica and fasciata Mihi Tab. the Sundanese call Toeloesoer.

Oxygaster Mihi, especially distinguished by a knife-like keel on the abdominal surface, is perhaps incorrectly placed in the Cyprinacae by me, for which reason I will come back to this later on. I have written *Anomalura* as the species name under the figure.

34. This brief diagnosis would adequately characterise the species (and the genus). There are no other Javanese Cobitids with similar features.

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Explanation of Plates

PLATE 3.

1. Russel, 1803, pl. XII: *Zygaena indica* van Hasselt.

PLATE 4.

3. Seba, 1758, pl. 24, fig. 18: *Monacanthus sarothrura* van Hasselt.
4. Gronovius, 1763, pl. 6, fig. 5: *Monacanthus sarothrura* van Hasselt.

PLATE 5.

5. Russel, 1803, pl. CLXXII: *Saurus carinatus* van Hasselt.

PLATE 6.

6. Russel, 1803, pl. CLXXXVII: *Engraulis indicus* van Hasselt.

PLATE 7.

7. Russel, 1803, pl. CCVII: *Lutodeira indica* van Hasselt.

PLATE 8.

8. Russel, 1803, pl. CLXXVI: *Belone strongylura* van Hasselt.

A small Collection of Bats from Selangor, Malaya

By D. Dwight Davis

Chicago Natural History Museum

(Received January, 1959)

The Chicago Natural History Museum recently received, as a gift from J. L. Harrison[1] of Kuala Lumpur, a small collection of bats in spirit. The collection numbers sixty-three specimens, representing six species of the genera *Rhinolophus* and *Hipposideros,* from several localities, all in the vicinity of Kuala Lumpur, Selangor. These are among the commonest of Malayan bats, but two of the forms represented by large series in the present collection have never been adequately described.

Hair colors are described from specimens temporarily dried by working fine sawdust through the hair and then blowing a stream of compressed air through it. Skulls of several specimens were removed and cleaned. In species represented by large series, skulls were removed from individuals of both sexes and representing the size range of the series.

Rhinolophus sedulus edax Andersen

Rhinolophus edax Andersen, 1918, *Ann. Mag. Nat. Hist.,* (9) **2:** 378—Singapore.
Rhinolophus sedulus edax Chasen, 1940, *Bull. Raffles Mus.,* **15:** 40.

General color dark brown above and below, nose leaf heavily pigmented. Forearm 38; skull, front of canine to condyle 16.6, zygomatic breadth 9.5, canine to rear of last upper molar, 7.0.

This specimen, an adult male, is considerably smaller than the measurements given by Andersen (forearm 48.5–50, canine to last upper molar 8.4–8.5), but agrees with *sedulus* in all other respects. Dimensions are closer to those of *R. s. sedulus* of Borneo than to *edax.*

Specimens examined.—Bukit Lagong Forest Reserve, Selangor (1).

Rhinolophus trifoliatus trifoliatus Temminck

Rhinolophus trifoliatus Temminck, 1834, *Tijdschr. Nat. Geschied. Physiol.,* **1:** 24—Java.
Rhinolophus trifoliatus trifoliatus Chasen and Kloss, 1931, *Bull. Raffles Mus.,* **6:** 47.

Both specimens are adult males. The coloration lacks the 'drab' or 'dirty buff' character usually described for this species. One specimen is buffy brown above, paler on the head, and buff washed with pale brown below; lips and chin buff. The second individual is paler, almost golden brown above, and buff below. Hairs slightly paler at base in both specimens. Nose leaf unpigmented.

Forearm 50.5, 50.8; canine to condyle 19.0, 20.2; zygomatic breadth 11.2, 11.6; canine to rear of last upper molar 8.5, 8.6.

Specimens examined.—Kepong Forest Reserve, Selangor (2).

Hipposideros armiger debilis Andersen

Hipposideros armiger debilis Andersen, 1906, *Ann. Mag. Nat. Hist.,* (7) **17:** 37—Province Wellesley (= mainland opposite the Island of Penang) Malayan Federation.

1. Dr. J. L. Harrison, formerly Zoologist at the Institute of Medical Research, Kuala Lumpur (1948–58).

This form is sufficiently characterized by its large size, which exceeds that of any other Malayan species of *Hipposideros*. The single specimen exhibits all the characters of the species and subspecies as given by Andersen. Color reddish brown above and below, the hairs darkest at the tips. Nose leaf agreeing with Andersen's description, slightly pigmented.

The skull is badly damaged but exhibits the characters described by Andersen: nasals not inflated, a foramen in center of nasofrontal region, infraorbital foramen wider than in *H. diadema*. The middle of the zygomatic arch is broader vertically than in *H. diadema*.

Foreman 95.5, tail 54, tibia 42.5.

Specimens examined.—Batu Cave, near Kuala Lumpur, Selangor, one adult male in alcohol.

Hipposideros diadema vicarius Andersen

Hipposideros diadema vicarius Andersen, 1905. *Ann. Mag. Nat. Hist.* (7) **16:** 499.—Niah Cave, Sarawak.

Forearm 81, tail 47, tibia 35.5. Skull, canine to condyle length 28.5, zygomatic breadth 18, front of canine to rear of last molar 13.2.

Specimens examined.—Kepong Forest Reserve, one adult male.

Hipposideros gentilis atrox Andersen

Hipposideros gentilis atrox Andersen, 1918, *Ann. Mag. Nat. Hist.*, (9) **2:** 380—Semangko Pass, Selangor-Pahang Boundary, Malayan Federation.

The species *gentilis*, along with several subspecies including *atrox*, was proposed by Andersen in a key. Evidently this preliminary diagnosis was intended to be followed later by more detailed descriptions. These descriptions never appeared, and the forms of *gentilis* are still very inadequately known. The present series of *atrox* was taken not far from the type locality, and may be considered essentially topotypic.

Color of upper parts brown, but with buff undercoloring showing through in irregular patches; individual hairs buff through most of their length, with brown tips. Under parts buff washed with brown. Face buffy brown, chin buff. Nose leaf small and slightly pigmented, without lateral leaflets, its upper part divided into four cells by three vertical ridges.

Mean and extreme length of forearm in nineteen adult males 43.7 (42.5–45.5), in nine adult females 44.1 (43.3–45.3). These measurements are entirely within the range given by Andersen. Five skulls (4 males, 1 female) measure: condyle to front of canine 16.1 (15.9–16.2), zygomatic breadth 9.6 (9.6–9.7), front of canine to rear of last upper molar 6.7 (6.6–6.9). First upper premolar minute, displaced from toothrow, canine and second premolar in contact. First lower premolar large, more than half the height of second premolar, cuspidate.

Specimens examined.—Total 37. Kepong Forest Reserve (23), Bukit Lagong Forest Reserve (13), Ulu Langat Forest Reserve (1).

Hipposideros galeritus galeritus Cantor

Hipposideros galeritus Cantor, 1846, *Jour. Asiatic Soc. Bengal*, 1846: 183—Penang.

The species *galeritus* is immediately distinguishable from other Malayan species of *Hipposideros* by the presence of a median spine on the posterior edge of the bony palate.

General color of upper parts dark brown, with buff basal portions of hairs showing through. The anterior half of the body is distinctly paler than the posterior half, the colors of the two regions sharply separated. Under parts buffy washed with brown, the hairs buffy terminally and brown at base. Face brown, chin buff, without tubercles. Nose leaf small, unpigmented, with two small secondary leaflets, its upper part divided into four cells by three vertical ridges.

Mean and extreme length of forearm in nine adult males 49.4 (48.4–50.5), in eight adult females 49.9 (49.0–51.0). Five skulls (3 males, 2 females) measure: condyle to front of canine 16.2 (16.0–16.3), zygomatic breadth 10.2 (10.0–10.3), front of canine to rear of last upper molar 6.7 (6.6–6.8). First upper premolar minute, displaced from toothrow, canine and second premolar in contact. First lower premolar large, more than half the height of second premolar, cuspidate. One skull, an adult female, has two upper incisors on each side.

Specimens examined.—Total 21. Kepong Forest Reserve (16), Bukit Lagong Forest Reserve (4), Ulu Langat Forest Reserve (1).

The Distribution of Mammals and Birds in the South China Sea and West Sumatran Islands

By E. BANKS

formerly Curator, Sarawak Museum, Kuching

(Received January, 1958)

THAT PART of the South China Sea between Malaya, Sumatra and Borneo is beset with islands, large and small, deep water and shoal.

The Riau Islands are sometimes large and high, in shallow water ten to fifteen fathoms deep, five to ten miles from Singapore. Batam Island covers 120 square miles, Bintang 325 square miles. Karimon Island is 1,500 feet and Durian 1,000 feet high. Other large high islands lie in ten to fifteen fathoms, within ten miles of Sumatra's east coast. Lingga covers 240 square miles and is nearly 4,000 feet high, Singkep 220 square miles and 1,500 feet high, Banka 2,800 square miles and 2,300 feet high. Billiton is half way between Sumatra and Borneo, still in ten to fifteen fathoms covering 1,600 square miles and 1,700 feet high. Bunguran Island in the North Natuna group, far out to sea between Malaya and Borneo, lies in thirty-five to forty fathoms, covers 100 square miles and rises to 3,000 feet. These are islands large enough for any animals. None have the highland fauna found above 3,000 feet on Malaysian mountain tops.

The Karimata, Tambelan and South Natuna island groups include many small islands, none of which cover more than ten square miles. All lie close to Borneo's west coast, in ten to fifteen fathoms and a few reach 1,000 feet in height. Many of the small Anamba islands, lying in twenty-five to thirty fathoms, far out to sea between Malaya and Borneo cover twenty-five to thirty square miles and rise to 1,800 feet.

These islands are the tops of submerged mountain chains, tectonically continuous with ranges in Malaya and Borneo. Billiton, Banka, Lingga and Karimon and Kunder Islands in the Riau group are continuations of Malaya's main range. Singkep and Batam Islands join the Gunong Tahan range and Bintang Island in the Riau group is a relic of the east coast range. Similarly the Anamba and Tambelan Islands join the Schwaner mountains in west Borneo, the North and South Natuna Islands join up with the Muller Mountains in Central Borneo.

Pleistocene glaciations have thrice dried out the shallow South China Sea, at the most to a depth of forty fathoms. The islands were then joined together and to Malaya, Sumatra and Borneo by Sundaland. This great plain was divided into two by the Great Sunda River, rising between Billiton and Borneo and running north east between the North and the South Natuna Islands. This now drowned river bed can still be traced on the charts. Inter-glacial floodings have separated the islands several times. Higher relative sea levels than at the present time have submerged low, shallow water islands and cut up some of the larger ones.

Off the west coast of Sumatra lie eight island groups. Simalur Island furthest north lies in about 200 fathoms, covers 500 square miles and is 1,800 feet high. The Banyak Islands are small, and lie in thirty-five fathoms, the largest covering only twenty square miles but rising to 1,000 feet high. Nias lies in 100 fathoms, more or less, covers 1,200 square miles and is 2,600 feet high. The small Batu Islands lie in thirty-five fathoms, the larger islands covering twenty square miles and rising to 800 feet. Siberut, Sipora

and Pagi, lying in just over 100 fathoms and known as the Mentawi Islands, cover 600 to 700 square miles each and rise to 1,000 feet. Engano lies alone in nearly 500 fathoms with an area of about 200 square miles.

The Banyak and the Batu Islands lie each on a different submarine bank connected with Sumatra's west coast. It may be that Nias is almost joined to the Banyak Islands and Siberut to the Batu Islands: it is not clear from the soundings.

Tectonically, these islands are the tops of a submerged mountain range, continuous with the Andaman and the Nicobar Islands to the north and with Sumba and Timor to the east.

The distribution of all but the peculiar species of mammals is given in TABLE A.

Let us suppose Banyak, Nias and Batu Islands were connected with Sumatra's west coast. Interglacial flooding impoverished the Banyak and Batu Islands: seven Sumatran species were relict on the deeper water Nias Island (Nos. 1 to 7). In the next glacial, the Batu Islands re-emerged and received seven species at first (Nos. 8 to 14). Later the Banyak Islands re-emerged and with the Batu Islands received another seventeen species, (Nos. 15 to 31) including three which already lived on Nias (Nos. 21, 22 and 31).

In the South China Sea Islands twelve species of mammals are found in the majority of the island groups from east to west (Nos. 9 and 19 to 29). With two exceptions they are not found in Nias but are present in the Banyak and Batu Islands. Thirteen mammals are found in the Riau, Banka and Billiton and in the Anamba and North Natuna groups (Nos. 5 to 18). They do not reach the shallow water South Natuna, Tambelan and Karimata groups, east of the Great Sunda River. Malayan *Ratufa bicolor* and *Sus cristatus* reach the North Natunas but not Borneo: Bornean *Tarsius* and *Ptilocercus* reach the South Natunas but not Malaya. Nine mammals have a uniform distribution in the majority of the shallow water islands east and west but are absent from the deeper water Anamba and North Natuna Islands (Nos. 30 to 38). With two exceptions they are absent from the Banyak and Batu Islands in the same depth of water.

When Sundaland dried out to its maximum in the severest glacial period, the mammals went to all the present South China Sea islands, unless stopped by the Great Sunda River. They seem to have gone to the Batu Islands and sometimes to the Banyak Islands but not to Nias. When Sundaland was less dried out in milder glacials, mammals went to the shallower water islands in the South China Sea but to the deeper water Anamba, North Natuna, Banyak and Batu Islands not at all.

If you collect lowland birds in the Malay Peninsula, forty-six are not found in Malacca or Johore. They are subhighland and their distribution ends with the main range in Selangor. If you collect lowland birds in Sumatra, twenty-six are absent from that part north of Padang Sidempuan in Lat. 1° 30′ N. Here in young Miocene times an arm of the sea is said to have separated north and south Sumatra. If you collect lowlands birds in Borneo, twenty-seven are not found north of the fourth parallel. North Borneo is almost separated from the rest by the tributaries of the Padas river to the west and the basin of the Sembakong river to the east. If you collect lowland birds in Java, forty-two are found in the west and centre but not in the east. The dividing line is the low lying plain between Semarang and Djokjarkata in 110° E. Another fifty-five species are found in Malaya, Sumatra and Borneo but are absent from Java.

These *Half-Siders* (half-Malayan or half-Sumatran or half-Bornean of half-Javan or non-Javan) are not as a rule found in the Philippines or in the Lesser Sunda islands. When found at all in the South China Sea islands or in the West Sumatran islands, they are found in one quarter or less of the sixteen possible island groups (TABLE B, Nos. 1

Table A

	Simalur	Banyak	Nias	Batu	Mentawi Is	Riau Is	Banka	Billiton	Anamba Is	North Natuna	South Natuna	Tambelan Is	Karimata Is
1. *Felis bengalensis*	.		X			R	.	.	.	.			
2. *Arctictis binturong*	.		R			X	R	.	.	.			
3. *Cervus unicolor*	.		R			.	X	X	.	.			
4. *Muntiacus muntjac*	.		R			X	X	X	.	.			
5. *Rattus concolor*	X		R			X	.	X	X	X			
6. *Rattus cremoriventer*	.		R			.	[R]	[R]	R	.			
7. *Manis javanica*	.		X			X	X	X	.	X			
8. *Hylopetes sagitta*	.				R	R	R	.	.	R			
9. *Sciurus lowii*	.			2R	R	R	.	.	.	[R]	[R]		
10. *Petaurista petaurista*	.			R	.	R	.	.	.	R			
11. *Tupia glis*	.			2R	R	4R	R	.	3R	R			
12. *Arctogale trivirgata*	.			X	R	4R	R	.	3R	R			
13. *Pithecus femoralis*	.			X	.	2R	.	.	.	R			
14. *Lariscus insignis*	.			R	R	R	.	.	.	R			
15. *Sciurus tenuis*	.	2R		R	.	X	.	.	R	R			
16. *Sus cristatus*	X	R		R	.	2R	.	.	.	R			
17. *Ratufa bicolor*	.	R		R	.	.	.	.	R	R			
18. *Rattus sabanus*	.	2R		R	R	R	.	.	R	R			
19. *Rhinosciurus laticaudatus*	.	R		.	R	R	.	.	R	[R]	[R]		
20. *Ptilocercus lowii*	.	.		X	.	X	X	.	.	R			
21. *Macacus irus*	.	.	X	R	X	X	X	X	[R]	[R]	[R]	[R]	X
22. *Tragulus javanicus*	.	.	R	R	R	9R	R	R	3R	3R	2R	.	.
23. *Galeopterus variegatus*	.	R		2R	.	R	X	.	[R]	[R]	R	.	R
24. *Sciurus notatus*	.	3R		R	.	4R	R	R	R	2R	2R	3R	R
25. *Rattus surifer*	.	3R		2R	R	R	.	.	R	R	R	.	R
26. *Tragulus kanchil*	.	2R		2R	.	2R	R	.	.	2R	.	.	R
27. *Macacus nemestrinus*	.	X		X	.	X	X	X	.	.	.	.	X
28. *Ratufa affinis*	.	2R		3R	.	7R	R	R	.	2R	R	R	.
29. *Rattus mülleri*	.	3R		2R	.	2R	R	.	R	R	R	.	.
30. *Tupia tana*	.	R		2R	.	R	.	.			R	R	.
31. *Rattus whiteheadi*	.	R	R	R	.	X	X	X			R	.	.
32. *Pithecus pyrrhus*	.				.	X	X	X			R	.	.
33. *Rattus rajah*	.				.	R	.	.			R	.	.
34. *Tarsius tarsier*	.				.	.	X	R			R	.	.
35. *Viverra tangalanga*	.				.	X	X	.			.	.	X
36. *Sciurus prevostii*	.				.	2R	R	R			R	2R	R
37. *Nannosciurus melanotis*	.				.	R	R	.			R	.	.
38. *Nycticebus coucang*	.	.		R	R	R	R	.	R	R	R	.	.
39. *Rattus canus*	.	R		.	.	.	.	.	.	.	.	.	.
40. *Hemigale derbyanus*	.	.		.	R	.	.	.	.	.	.	.	.
41. *Iomys horsfieldii*	.	.		.	R	.	.	.	.	.	.	.	.

Table B

	Simalur	Banyak	Nias	Batu	Siberut	Sipora	Pagi	Engano	Riau Is	Banka	Billiton	Anamba Is	North Natuna	South Natuna	Tambelan Is	Karimata Is
HALF-BORNEAN																
1. *Anthracoceros coronatus*	·	·	X	X	[R	R	R]	·	·	·	·	·	R	·	·	·
2. *Anaimos maculatus*	·	·	R	·	·	·	·	·	·	·	X	·	X	·	·	·
3. *Dicaeum concolor*	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
4. *Ichthyophaga nana*	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
5. *Batrachostomus auritus*	·	·	·	·	·	·	·	·	·	·	R	·	X	·	·	·
6. *Chotorea rafflesi*	·	·	·	·	·	·	·	·	·	X	R	·	·	·	·	·
7. *Euptilosus euptilosus*	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·	·
8. *Eupetes macrocercus*	·	·	·	·	·	·	·	·	·	·	·	·	X	·	·	·
9. *Aethostoma rostratum*	·	·	·	·	·	·	·	·	X	·	X	·	·	·	·	·
10. *Anaimos thoracicus*	·	·	·	·	·	·	·	·	·	·	X	·	·	·	·	·
HALF-MALAYAN																
11. *Culicicapa ceylonensis*	[R	·	R]	·	X	X	X	X	X	·	·	·	X	·	·	·
12. *Accipiter trivirgatus*	·	·	X	·	·	·	·		·	·	·	·	X	·	·	·
13. *Strix leptogrammica*	·	R	R	·	·	·	·		·	·	·	·	X	·	·	·
14. *Ictinaetus malayensis*	·	·	X	·	·	·	·	·	·	·	X	·	·	·	·	·
15. *Phodilus badius*	·	·	X	·	·	·	·	·	·	·	X	·	X	·	·	·
16. *Anthreptes simplex*	·	·	X	·	·	·	·	·	·	·	·	·	X	·	·	·
17. *Rhinomyias umbratilis*	·	·	R	·	·	·	·	·	X	·	X	·	X	·	·	·
HALF-SUMATRAN																
18. *Pericrocotus igneus*	R	·	X	·	·	·	·	·	·	·	X	·	·	·	·	·
19. *Ceyx erithacus*	·	·	X	·	·	·	·	·	X	·	X	·	·	·	·	·
20. *Orthotomus sericeus*	·	·	X	·	·	·	·	·	·	·	·	·	·	·	·	·
HALF-JAVAN																
21. *Aethopyga siparaja*	[R	R	R]	·	[R	R	R]	·	X	·	·	X	X	·	·	·
22. *Irena puella*	·	X	X	X	X	X	·	·	·	·	·	·	·	·	·	·
23. *Sasia abnormis*	·	·	R	·	·	·	·	·	·	·	X	·	·	·	·	·
24. *Pitta sordida*	·	·	X	·	·	·	·	·	·	R	R	·	·	·	·	·
25. *Micropternus brachyurus*	·	·	R	·	·	·	·	·	·	·	X	X	X	·	·	·
26. *Meiglyptes tristis*	·	·	R	·	·	·	·	·	·	·	·	·	X	·	·	·
27. *Arachnothera chrysogenys*	·	·	R	·	X	X	·	·	X	·	·	·	·	·	·	·
28. *Spizaetus nipalensis*	X	X	X	·	·	·	·	·	·	·	·	X	·	·	·	·
29. *Prinia flaviventris*	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·
ALL-MALAYSIAN																
30. *Treron vernans*	R	R	R	[R	R	R]	R	R	X	X	X	R	X	X	R	X
31. *Ceyx rufidorsis*	R	·	[R	R]	[R	R	R]	·	X	X	X	·	X	·	·	·
32. *Pycnonotus plumosus*	·	X	X	X	X	X	·	·	X	X	·	·	R	R	·	·
33. *Chalcosthetha chalcosthetha*	·	R	X	X	[R	R]	·	R	X	X	·	·	R	R	·	X
34. *Gracula javana*	R	R	R	[R	R	R]	·	R	X	X	X	R	X	X	R	X
35. *Copsychus malabarica*	R	R	R	R	[R	R]	·	·	X	R	R	R	R	·	·	X
36. *Hemiprocne longipennis*	R	·	R	R	·	[R	R]	R	X	X	X	X	X	·	·	X
37. *Ducula aenea*	R	[R	R]	[R	R	R]	·	R	X	X	X	X	X	X	X	X
38. *Leptocoma brasiliana*	R	·	R	X	X	X	·	·	X	X	X	R	R	·	·	·

to 29). Those birds found in the majority of the island groups (TABLE B, Nos. 30 to 39) belong to the ninety-two species found in all-Malaya, all Sumatra, all Borneo and all Java—the *Full-Timers*.

Among forty-six half-Malayan species, only *Culicicapa ceylonensis* (No. 1) is found in many islands. Ten others go to Nias and Billiton or North Natunas (Nos. 2 to 7), the rest to no islands at all. Of twenty-eight half Sumatran species, three are found in Nias and twelve in Billiton or the North Natunas (Nos. 8, 9, 10). Of twenty-seven half Bornean species, only five are found in Nias and thirteen in the South China Sea islands. In thirty-eight half Javan species, *Aethopyga* and *Irena* are found in many islands. Nine others are found in Nias and fourteen in two or three of the South China Sea islands (Nos. 21 to 29). Fifty-five non-Javan species (not shown in the table) have only *Aegithina viridissima* in many islands. Fifteen are found in Nias and fourteen in two or three of the South China Sea islands. Six are found only in Banka and seven only in the North Natuna group.

The *Half-Siders* do not turn up on many islands. If they do, it is on Nias or either Banka, Billiton or on Bunguran in the North Natuna group.

Here are ninety-two *Full-Time* all-Malaysian species. Fifty-four of these are found on the majority of the South China Sea and West Sumatran islands (TABLE B; Nos. 30 to 39, for example). Sixteen others are found freely in the South China Sea islands and ten on no islands at all. This leaves twelve all-Malaysian species in a minority of the islands —e.g. in Nias only are *Lalage, Trachycomus* and *Munia atricapilla.*

Most of the *Full-Time,* all-Malaysian species are found in the great majority of the islands.

For mammals, successive ice ages have determined their distribution across the Sundaland, joining the islands in the South China Sea to Malaya, Sumatra and Borneo. The same is true for the Banyak and Batu Islands with Sumatra's west coast.

For birds, glacial periods determined their distribution throughout the large islands of Malaysia and the majority of the small islands in the South China Sea and off the west coast of Sumatra. Geologists agree that in at least one interglacial period the sea level was about fifty feet higher than at present. This divided up Sumatra, Borneo and Java, limiting bird distribution to parts of these provinces. At the same time, dispersal during the interglacial period cut down bird distribution to a minority of the South China Sea and West Sumatran islands.

TABLES A and B show the distribution of mammals and of birds in the islands of the South China Sea and in the islands off the west coast of Sumatra. Their presence unaltered in the islands is indicated by an X, their presence as a peculiar subspecies by an R.

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Migration and Movements of Birds of Prey over Singapore

By L. H. HURRELL

(Received December, 1958)

PULAU BLAKANG MATI is a small island situated off the southern point of Singapore. It is well placed for observing the movements of birds leaving or arriving on the Malayan land mass. During a stay on the island of over eighteen months, I noted a number of migrating birds of prey and a curious movement of Brahminy Kites (*Haliastur indus*).

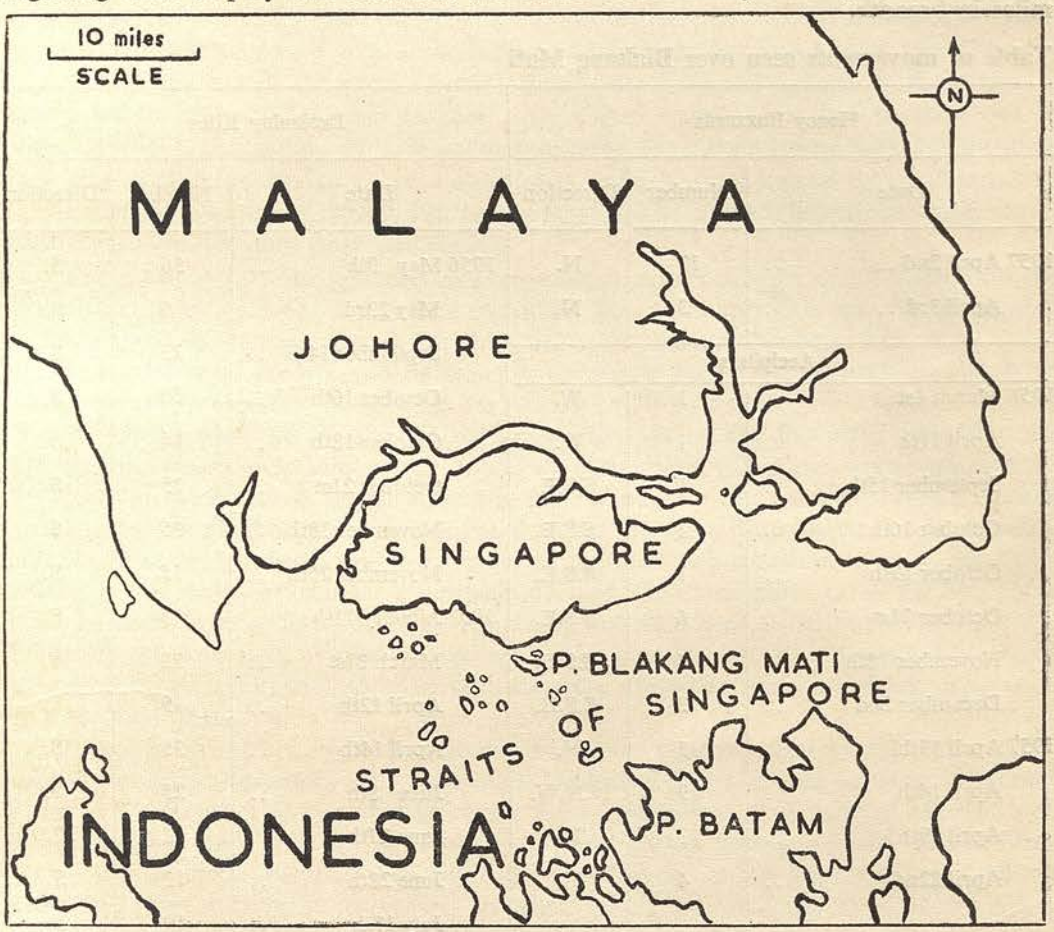

FIGURE 1. P. Blakang Mati, Singapore Island and neighbouring areas.

Migrations observed

Many birds of prey come as winter visitors to the southern part of the Malay peninsula, including the Osprey (*Pandion haliaetus*), and Peregrine (*Falco peregrinus*), but only Honey Buzzards (*Pernis apivorus*) and accipiters were observed migrating. A spring migration of Honey Buzzards was seen on April 2, 1957. At 17.30 hours, seventeen were watched going north in straggling circling parties and at 16.00 hours on April 3, a further three.

Small numbers of accipiters were seen frequently during autumn flying steadily south south-east, or circling high and making off with a group of Brahminy Kites across the Straits towards Indonesia. Many Japanese Sparrow Hawks (*Accipiter virgatus*) remain as winter visitors in the Malay Archipelago and the accipiters observed migrating were thought to be of this species. A return migration was observed in the spring of 1957. The peak occurred on April 14, when a total of nineteen passed over Blakang Mati. Ten were watched circling together to over one thousand feet and then making off north north-west at 10.00 hours. During the next two hours a further nine individuals passed north north-west flying at about one hundred feet. Several of these were coming in alone over the Singapore Harbour, the front of the observed migration being two miles in breadth.

Table of movements seen over Blakang Mati

Honey Buzzards			Brahminy Kites		
Date	Number	Direction	Date	Number	Direction
1957 April 2nd	17	N.	1956 May 9th ..	56	S.
April 3rd	3	N.	May 23rd ..	6	S.
Accipiters			September 14th ..	25	S.
1956 March 1st ..	1	W.	October 16th ..	50	S.
April 11th ..	1	W.	October 18th ..	84	S.
September 15th ..	1	S.S.E.	October 21st ..	35	S.
October 16th ..	1	S.S.E.	November 18th ..	35	S.
October 19th ..	1	S.S.E.	November 25th ..	15	S.
October 21st ..	6	S.S.E.	1957 January 11th ..	13	S.
November 18th ..	4	S.S.E.	March 31st ..	22	S.
December 2nd ..	2	S.S.E.	April 12th ..	19	S.
1957 April 13th ..	3	N.	April 14th ..	35	S.
April 14th ..	19	N.N.W.	June 8th ..	25	S.
April 19th ..	1	N.	June 27th ..	12	S.
April 22nd ..	4	N.	June 28th ..	12	S.
			July 17th ..	10	S.

Movements of Brahminy Kites

The Brahminy Kite is a plentiful species around the Malayan coast and the neighbouring islands. It is stated to be resident (Gibson-Hill) and I have been unable to trace any published records of sizeable or well marked movements of these birds. It was therefore a surprise to note from December 1955 to July 1957 a passage of them over Blakang Mati. During the early months of 1956, I noted that a number of Brahminy Kites would set off in the evening from the southern point of Blakang Mati and fly

between south and south-east out to sea. These birds could be followed past the smaller islands to the south and over the Straits of Singapore towards the Indonesian island of Batam some ten miles away. I felt at first that this must be some form of roosting behaviour but could see no definite return movement in the mornings. I did on a few occasions see two or three meandering north in the early hours but there was no convincing movement. Individuals would sometimes gather in the trees in the late afternoon near a small reservoir on Blakang Mati. Some would come down to drink, and later all or a few at a time, would take off and go south. A few birds could often be seen travelling south-east along the Blakang Mati shore to its southern tip and thence heading out to sea without necessarily joining up with the main parties. The method of progress appeared to depend upon the wind conditions; sometimes they would fly low and maintain an undeviating course and sometimes circle high before leaving the coast. In the latter case they would frequently again circle over the small islands to the south to regain height before continuing on their way. Often some of the last to leave did so when the light was fading rapidly so that it must have been quite dark by the time they reached the Indonesian shore. I sometimes watched from one of the southern-most of the Singapore group of islands (St. John's Island), and could follow them flying southwards until out of sight over the Straits.

The movements were recorded in every month except August and occurred on the majority of evenings when I was able to watch. The main variation was in the number of birds involved. Usually it was less than thirty but during October 1956 much larger numbers were seen. Birds could be seen on the move during the afternoon as early as 14.00 hours. On October 16 between 16.30 and 18.00 hours, fifty were counted and on October 19 between 16.50 and 17.30 hours, eighty-four. On the latter occasion, the weather was rough and many storm clouds were moving south. Kites were coming from the north at five hundred to one thousand feet. Groups of ten to twenty could be seen forming and circling together to gain height over Blakang Mati. After a few minutes, individuals started to break away from the group, and with measured beat to fly south, followed in a steady stream by the remaining birds. Looking east across the Singapore Harbour more kites could be seen moving south, although none could be seen to the west. Evidently the front was at least a mile wide. The parties were sometimes accompanied by migrating accipiters and on these occasions the movement gave a definite impression of a through migration.

It seems that this may be an autumn migration superimposed on the daily movements previously described, and that some Brahminy Kites in fact are true migrants. However, I saw no evidence of a northerly return movement in the spring of 1956 and 1957. Instead, there were the southbound evening parties setting off and on 9th May, 1956, fifty-six were counted streaming south. I watched closely whenever opportunities arose for other movements occurring anywhere along the southern coast of Singapore Island, but found no evidence of any.

Discussion

The overall picture is therefore of a southerly afternoon movement throughout the year which may possibly be roosting behaviour. The movements persist until such a late hour and the transition from day-light to darkness is so rapid that it seems certain that they must roost shortly after arriving in Indonesia. The answer might be forthcoming if one could observe their arrival and watch their departure in the morning but unfortunately the present political situation prevents such investigation. The Singapore

Harbour is undoubtedly attractive as a feeding area and probably explains the considerable numbers there during the day, but not the direction in which the evening movements occur, since there is no obvious reason why Indonesia should be preferred to Singapore Island or Johore. It is possible that the kites escape detection by wandering back leisurely during the morning over a very wide front but I did not succeed in demonstrating this satisfactorily.

The peak numbers in October suggest an autumn migration, partly because of the numbers involved and partly because movements were seen so much earlier in the day than would be likely if roosting was the sole purpose. The parties on such occasions were also frequently accompanied by migrating accipiters. The absence of any return migration in spring is remarkably difficult to explain, and the increased number of southbound kites in May is even more perplexing. More observations in the spring are needed before this can be regarded as a reverse migration but the evidence to date seems rather to suggest it.

Summary

Southbound autumn and northbound spring migrations of Honey Buzzards (*Pernis apivorus*) and accipiters (probably mostly *Accipiter virgatus*) were observed over Singapore during 1956 and 1957.

Autumn movements of Brahminy Kites (*Haliastur indus*) were observed, suggesting that some individuals may be migrants, but the significance of daily southbound movements throughout the year is uncertain.

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The Habitats of some minute Cyclophorids, Hydrocenids and Vertiginids on a Malayan Limestone Hill

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(Received July, 1961)

Introductory

STUDIES ON THE Cyclophorids, Hydrocenids, Vertiginids, and Streptaxids which inhabit limestone hills in South-East Asia have been limited to distributional and taxonomic surveys made by Tweedie, van Benthem Jutting, Laidlaw, and others. These have been based on dry shell material collected from debris around the bases of limestone outcrops. Thus, although much is known of distribution of these snails in Malaya (reviewed by Tweedie, 1961), many authors have emphasised how little is yet known of the ecology, general biology, and even the anatomy of these animals. Many species have not yet been seen alive.

Site and Method of Collecting

The present author has collected and studied live snails from Bukit Chintamani between Bentong and Karak in Pahang, (3° 27′ N., 102° 05′ E.). This is an isolated outcrop of Permian limestone, far-separated from Batu Caves to the West, Bukit Serdam to the North, and Gunong Sinyum to the North-East, (Paton, 1961).

Most of the western face of Bukit Chintamani is being quarried, leaving the eastern and southern faces relatively undisturbed (Fig. 1).

Trees and other vegetation grow on top of the hill, on the earthy scree around its base, and in places on narrow ledges on the otherwise nearly vertical limestone surfaces. This vegetation provides shade for much of the rock surface. During and after rain some areas of the rock remain damp and in many places there are extensive patches of moss. Other areas dry quickly after rain and some are directly exposed to the sun. No place remains wet after a few rainless days, and in long dry periods even the moss becomes dry and brittle. In some moss-free areas the rock surface is covered with lichen. Thus, animals living on the limestone walls may be subjected to conditions ranging from rain-soaked moss with water freely flowing down the rock to complete dryness and exposure to full sun.

The entire lower eastern part of the hill was searched for snails on nine occasions between February 1960 and June 1961, and within a selected 30 foot length of well-shaded rock face ("A" in Fig. 1), four-inch-square samples were taken at random from between ground level and seven feet above ground. A four-inch metal frame was used, and all material within it brushed into a container. This rock face "A" lies roughly on a line 115° east of North, thus facing about 25° east of North. It is thus well shaded during

the months of the northern winter, but receives sunlight during the northern summer. Large areas of this section are covered by moss, and there are areas, particularly at each end, where the rock is bare.

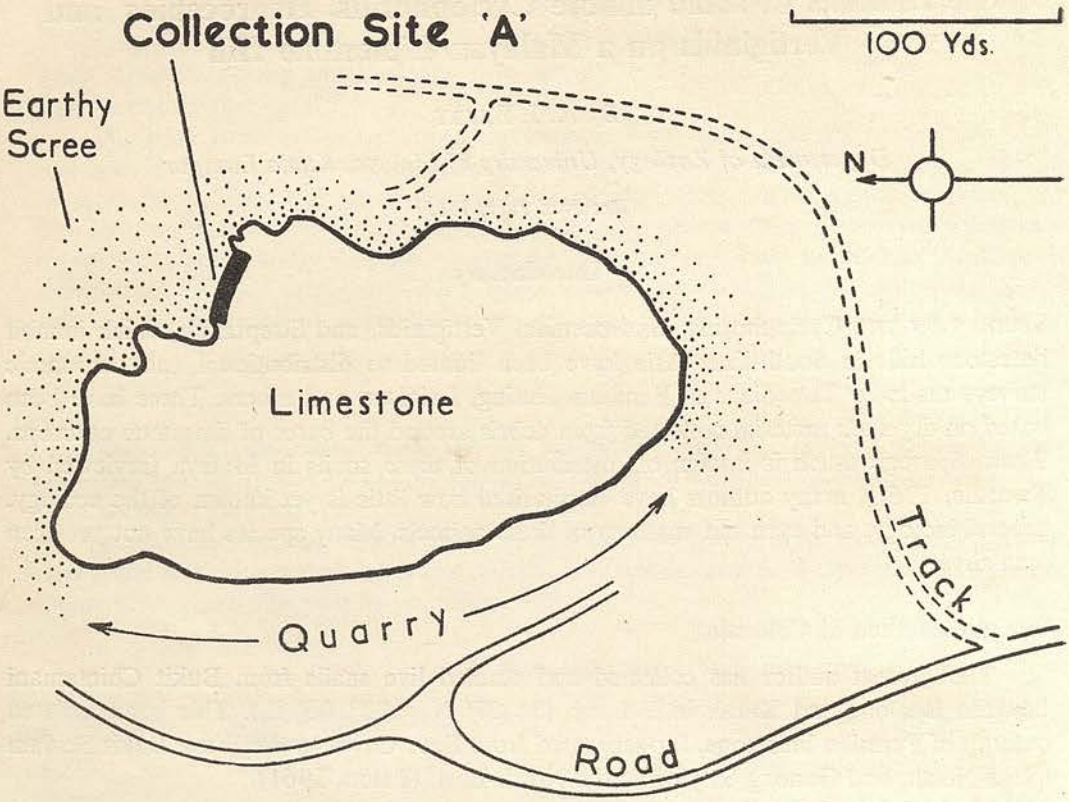

FIGURE 1

Sketch plan of Bukit Chintamani with the location of the site where four-inch-square samples were collected.

The gastropod fauna

The snails so far known from Bukit Chintamani include the following:— (see Tweedie, 1961):—

Cyclophoridae:	*Opisthostoma (Plectostoma) retrovertens* Tomlin
	Opisthostoma (Opisthostoma) hypermicrum van Benthem Jutting
	Diplommatina ventriculus v. Möllendorff
Hydrocenidae:	*Hydrocena monterosatiana* (Godwin Austen & Nevill)
Vertiginidae:	*Gyliotrachela hungerfordiana* (Möllendorff)
	G. depressispira van Benthem Jutting
	Hypselostoma terae Tomlin
Streptaxidae:	*Oophana eutropha* van Benthem Jutting
	Sinoennea chintamanis Tomlin

Of these I have so far found alive *Opisthostoma (P) retrovertens, Hydrocena monterosatiana, Gyliotrachela hungerfordiana, G. depressispira,* and *Hypselostoma terae.* It is possible that failure to find the remainder has been due to their low numbers or to their inhabiting special niches such as soil pockets in the rock, particular plants, or the less accessible parts of the hill.

Various other snails occur in the immediate neighbourhood of the hill. *Achatina fulicha* (Ferussac) is abundant. *Hemiplecta cymatium* (Pfeiffer), *Cyclophorus perdix tuba* (Sowerby), and others not limited to limestone regions, occur on the earthy scree around the hill.

The species on the limestone itself were found to have particular habitat requirements and occurred most abundantly in particular situations on the rock face. The areas directly exposed to the sun, with little or no shade, bore no snails or vegetation. Regions which were shaded and where there was complete lichen coverage had very few snails; snails were hardly ever found actually on lichen. Regions which were shaded and free of lichen and moss were inhabited by the two species of *Gyliotrachela* and by *H. monterosatiana.* Moss-covered areas yielded *O. retrovertens, H. monterosatiana,* and *G. hungerfordiana.*

Table 1 shows details of the occurrence of adult snails in four-inch-square samples collected in February 1960, December 1960, and in June 1961. *O. retrovertens* is seen to occur only on moss-covered rock, and has never been found on bare surfaces. *Hydrocena* occurs among moss and on bare rock, but in larger numbers in the former situation. *G. depressispira* was found only on bare rock, and never on moss. On the other hand *G. hungerfordiana,* while preferring bare rock, was also found in small numbers among moss. The numbers of *Hypselostoma* seem hardly sufficient to allow any conclusions as to its optimum habitat, and it is possible that greater numbers of this species may be found in situations as yet unlocated.

Except for *Opisthostoma,* all regions of Bukit Chintamani confirmed that the habitats of each species were as in the sampled region. *O. retrovertens* was only found in rock face "A". Similar rock faces with apparently identical moss coverage and other general conditions occur North and South of "A", but *Opisthostoma* was not found on them. At present no reason can be offered for the apparent restriction of this species to a relatively small part of the hill.

Discussion

Opisthostoma and *Hydrocena* are both prosobranches and respire by gills and a vascularised mantle wall. The gills, however, are reduced and probably play a small part in respiration. In periods of dryness both can close the shell aperture with the operculum, and *Opisthostoma* has survived four months on unmoistened dry moss in the laboratory; but while active both might be very susceptible to dessication. It seems likely that the air in a dense growth of moss will remain more constantly humid than that near a bare rock surface, and that this will be important to prosobranch snails.

Table 1 shows that the numbers of *Opisthostoma* and *Hydrocena* were greatest in the February 1960 collection, and that relatively few *Opisthostoma* were found in June 1961. Ten four-inch-square samples taken on 25th May, 1961 from moss covered areas in the collecting zone "A" contained an average of only 1.7 adult *Opisthostoma.* It may be that the heavier rainfall in the period September–January in this region of Malaya

TABLE 1

Numbers of snails in four-inch-square samples collected from rock-face "A", Bukit Chintamani.

Date	Species	Samples from Moss-Free Surfaces											Samples from Moss-Covered Surfaces										
		1	2	3	4	5	6	7	8	9	10	Ave.	1	2	3	4	5	6	7	8	9	10	Ave.
7–2–1960	*O. retrovertens*	0	0	0	0	0	0	0	0	—	—	0.0	10	11	12	13	8	23	19	22	—	—	14.7
	H. monterosatiana	9	11	9	7	7	10	8	6	—	—	8.4	16	14	14	15	12	5	11	8	—	—	11.9
	G. depressispira	7	9	3	6	3	4	5	5	—	—	5.3	0	0	0	0	0	0	0	0	—	—	0.0
	G. hungerfordiana	1	3	7	4	0	2	3	2	—	—	2.8	1	0	0	0	0	5	2	4	—	—	1.5
	Hypselostoma terae	0	0	0	0	0	0	0	0	—	—	0.0	0	0	0	0	0	1	0	1	—	—	0.25
14–12–1960	*O. retrovertens*	0	0	0	0	0	0	0	0	—	—	0.0	10	8	6	15	11	9	5	7	—	—	8.9
	H. monterosatiana	6	12	8	11	5	9	4	7	—	—	7.8	12	10	15	11	7	10	8	3	—	—	9.5
	G. depressispira	4	7	3	2	0	6	0	8	—	—	3.8	0	0	0	0	0	0	0	0	—	—	0.0
	G. hungerfordiana	3	0	3	6	2	3	5	0	—	—	2.8	0	2	1	0	0	1	2	0	—	—	0.8
	Hypselostoma terae	0	0	0	0	1	0	0	0	—	—	0.13	0	1	0	0	0	0	0	0	—	—	0.13
26–6–1961 (moss-free)	*O. retrovertens*	0	0	0	0	0	0	0	0	0	0	0.0	4	3	3	8	7	3	5	3	12	4	5.2
	H. monterosatiana	11	3	2	19	9	12	6	2	1	8	7.3	11	8	18	3	32	6	8	2	6	5	9.9
	G. depressiapira	2	0	2	2	0	13	6	7	3	11	4.6	0	0	0	0	0	0	0	0	0	0	0.0
21–6–1961 (moss-covered)	*G. hungerfordiana*	1	2	1	6	7	0	0	0	1	1	1.9	0	0	1	1	0	0	0	0	0	0	0.2
	Hypselostoma terae	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0.0

(Dale, 1959), may cause a seasonal increase in the numbers of snails at this time, and that the relatively dry period of February–August may cause mortality or a slowing in the reproductive rate.

Gyliotrachela on the other hand is an air breathing pulmonate, and thus less likely to be affected by dryness and fluctuations in the humidity of the air. During long periods of dryness individuals seal the rim of the aperture to the dry rock surface with mucus and remain immobile. In the laboratory this inactive period has lasted up to 34 days in the case of *G. depressispira,* when activity commenced on moistening.

Besides respiratory and water-loss considerations, the food of the snails appears to be correlated with their habitats. The stomachs of dissected *Opisthostoma* contained mostly groups of algal cells, scraped from the rock and moss, and occasional fragments of moss itself. *Hydrocena* stomachs contained algae, fragments of moss, and in the case of those on bare rock, varying amounts of lichen. The stomachs of *Gyliotrachela* usually contained algal cells, often large amounts of lichen, but never fragments of moss.

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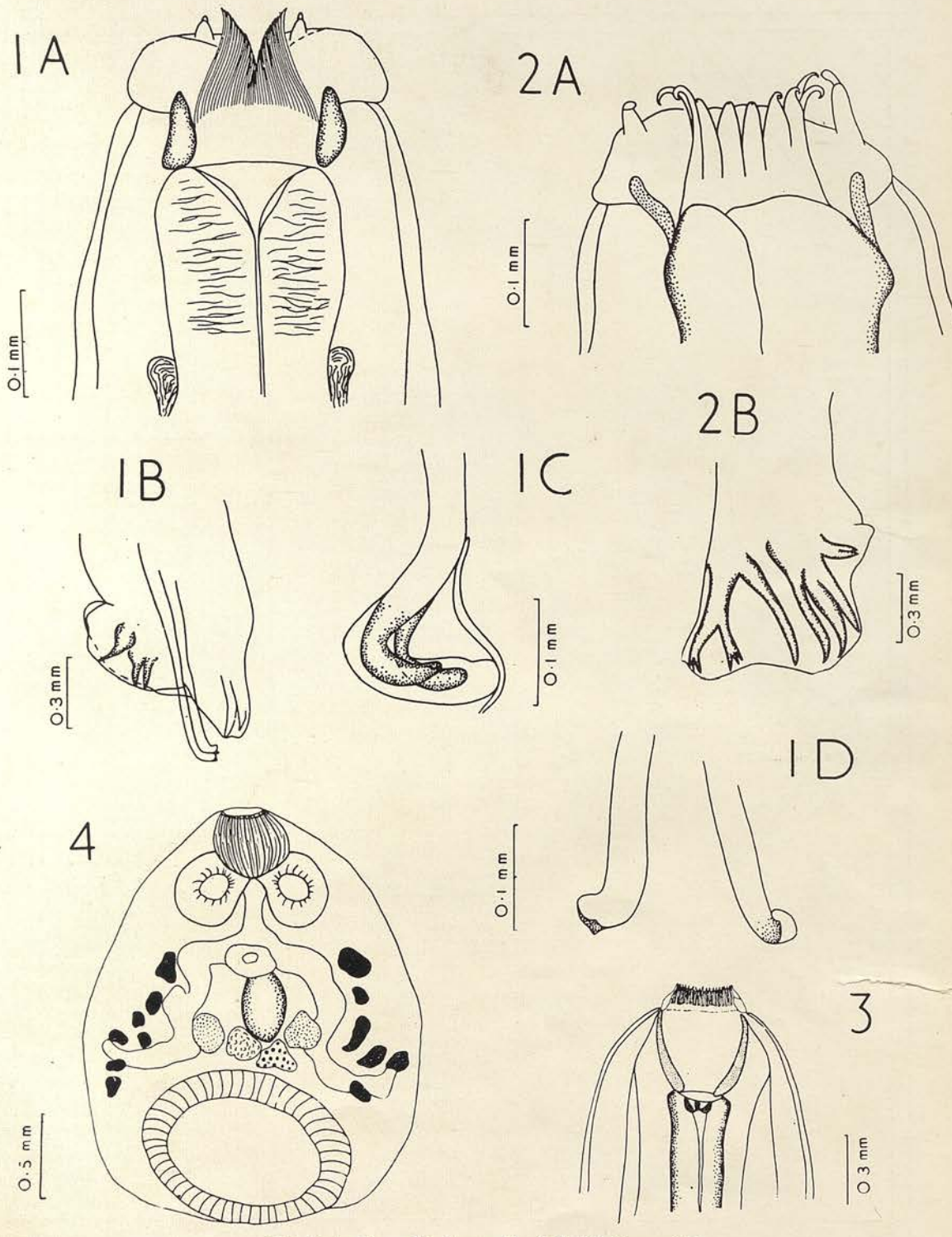
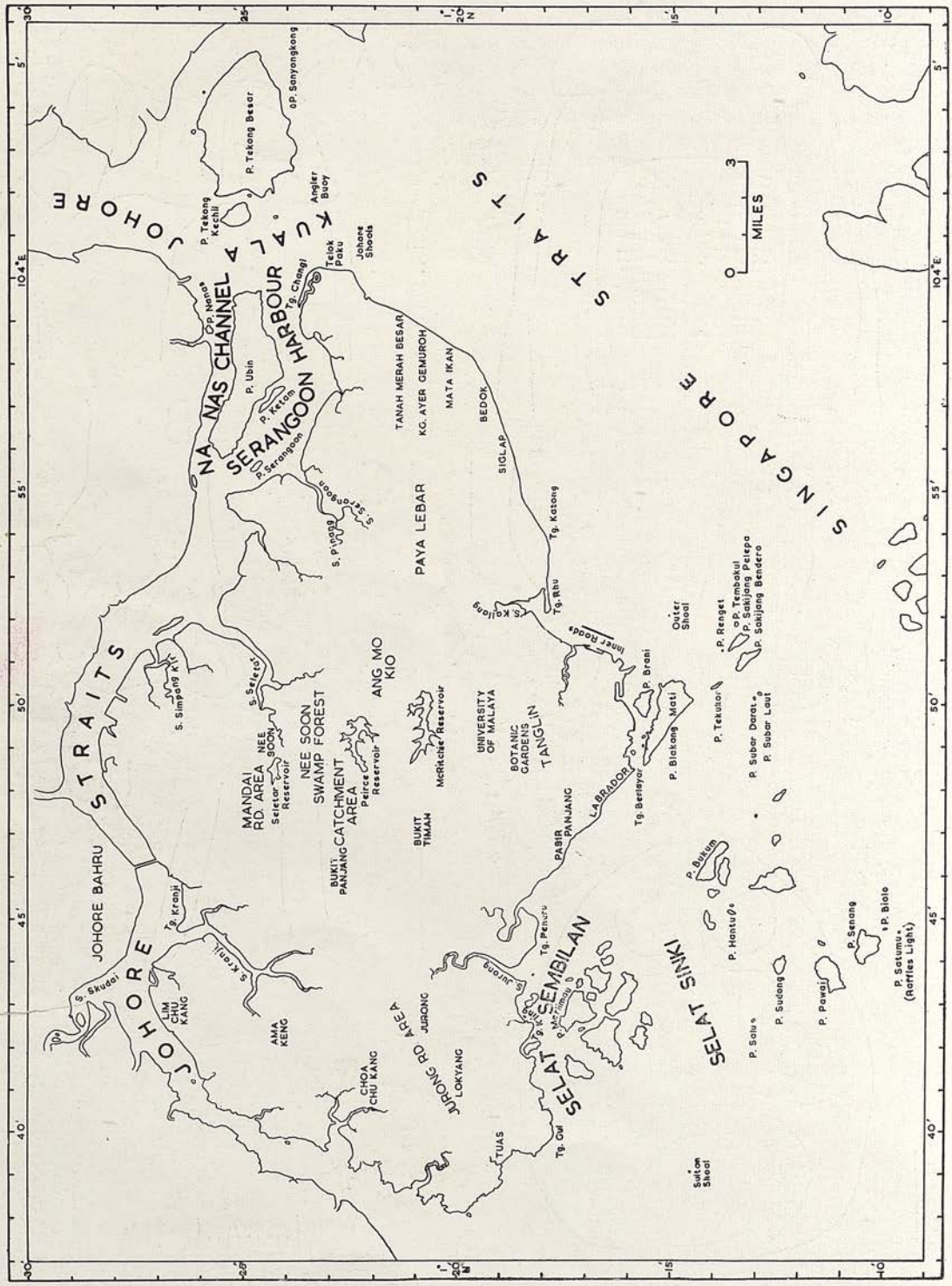


Helminths from Elephants (A. & C. H. Fernando).



Caridea and Stenopodidea (D. S. Johnson).

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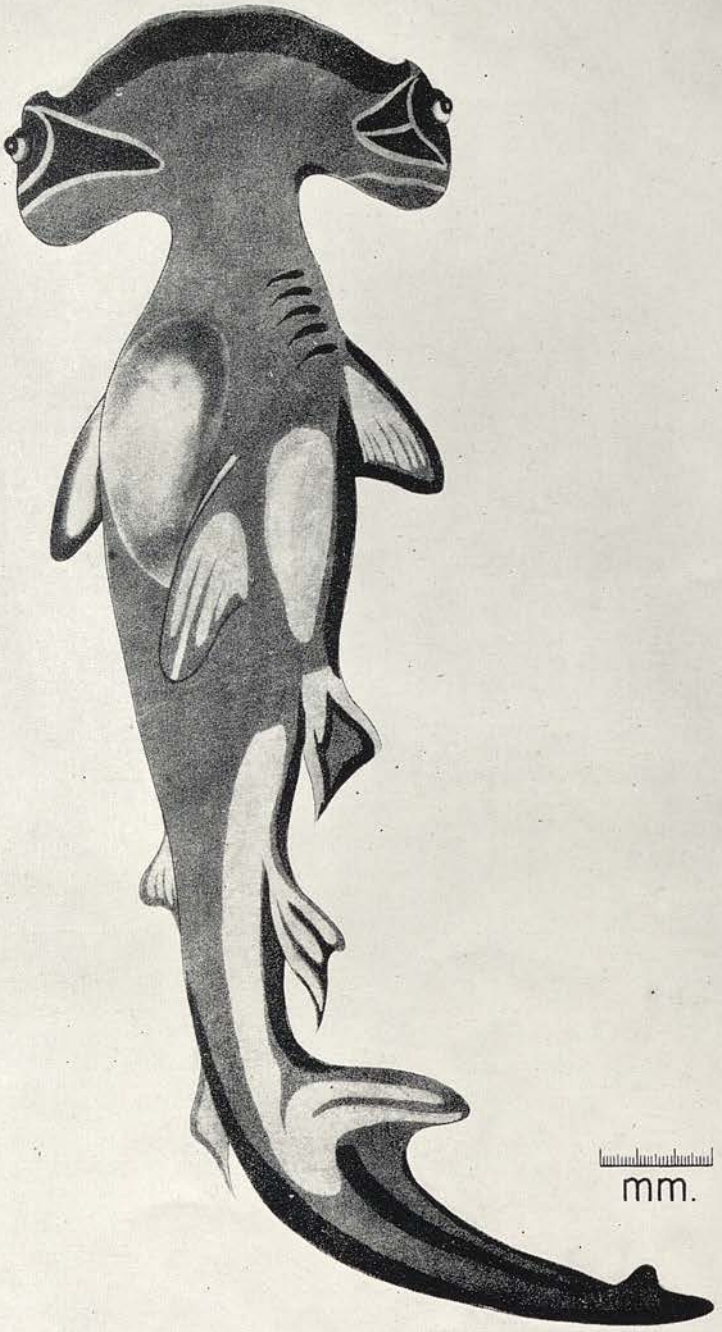
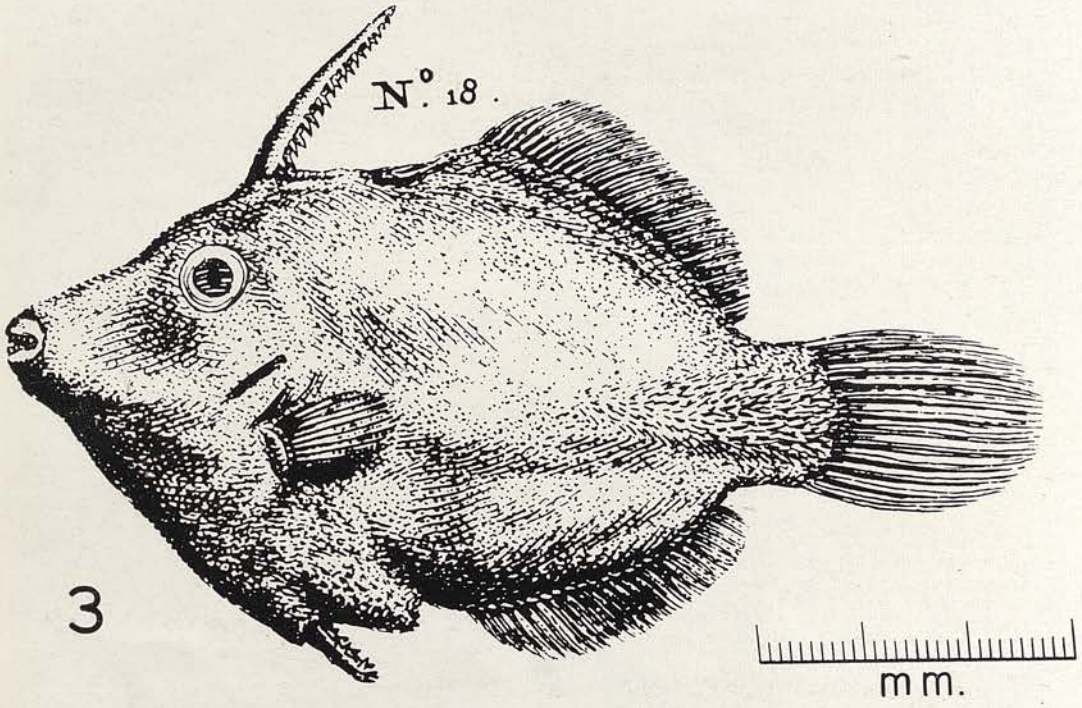
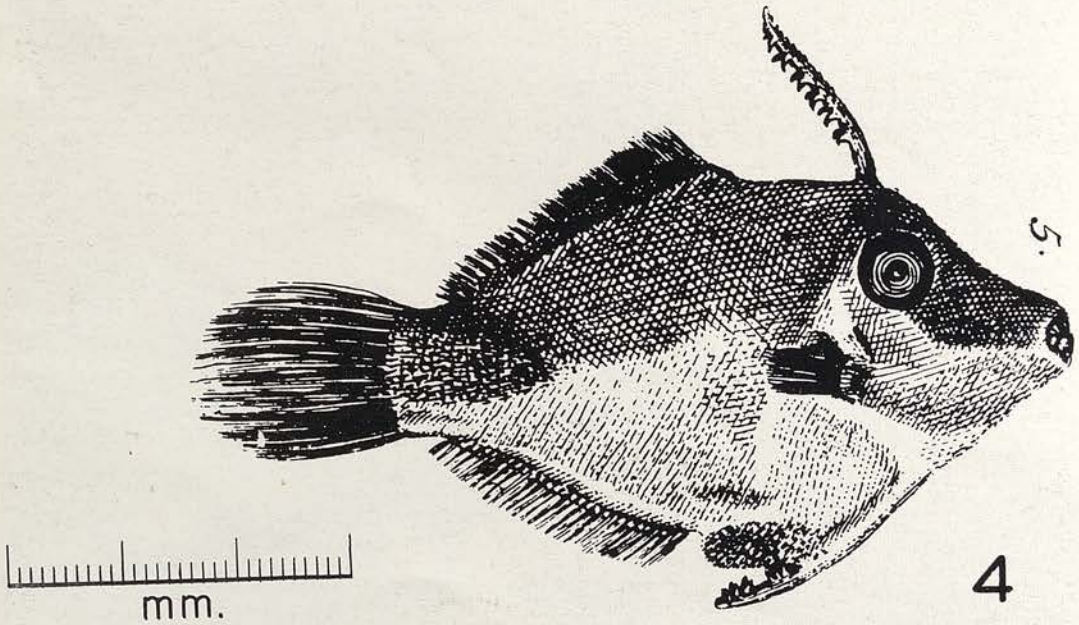


KOMA SORRA.

Kuhl and van Hasselt (Eric R. Alfred).





Kuhl and van Hasselt (Eric R. Alfred).

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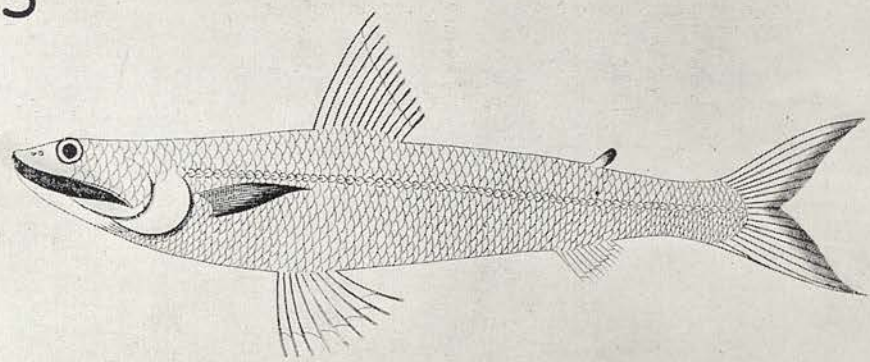

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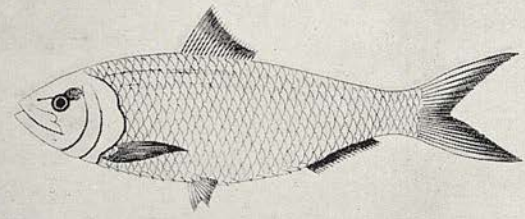
BADI MOTTAH

Kuhl and van Hasselt (Eric R. Alfred).

CLXXXVI. CLXXXVII.



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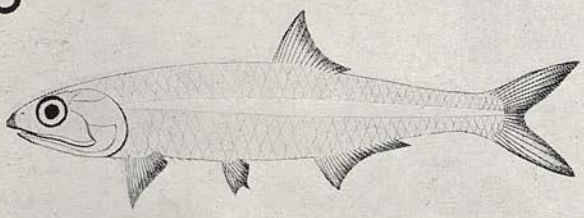

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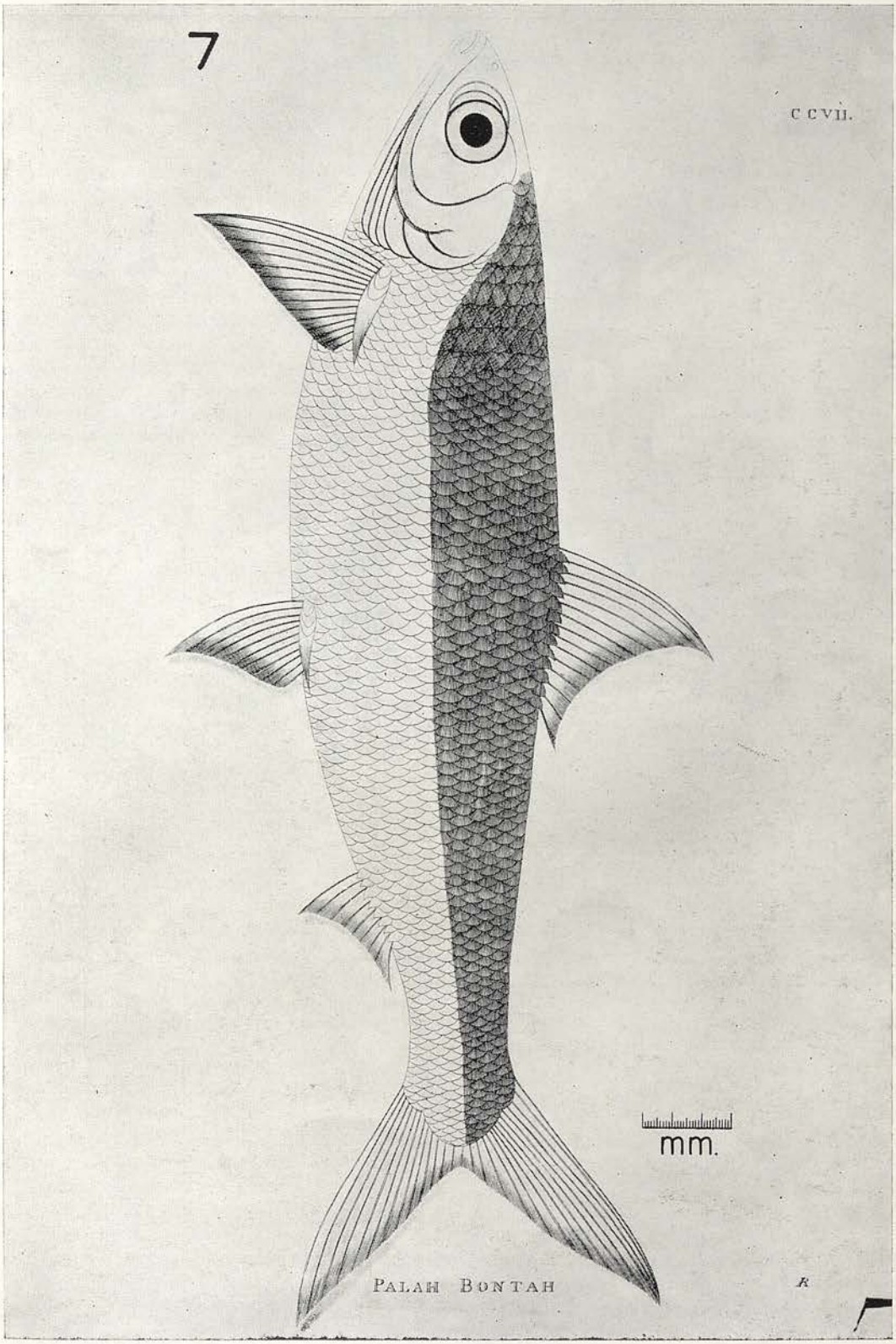

Kuhl and van Hasselt (Eric R. Alfred).

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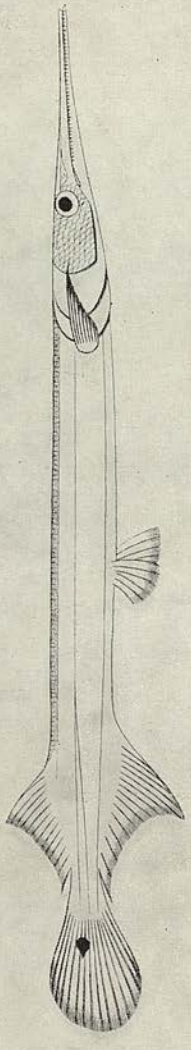

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Kuhl and van Hasselt (Eric R. Alfred).